NATIONAL
ELECTRIC LIGHT
ASSOCIATION

Twenty-ninth Convention
Atlantic City, N. J.
June 5, 6, 7, 8, 1906


ORA ET LABORA
ARTHUR EDWIN KENNELLY

F. H. Blood Jr.

NATIONAL

Electric Light

AS...

TWENTY-...

Papers, Reports ...

PUBLISHED BY ...

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NATIONAL

Electric Light

ASSOCIATION

TWENTY-NINTH CONVENTION

VOLUME I

Papers, Reports and Discussions

ATLANTIC CITY, NEW JERSEY

JUNE 5, 6, 7, 8, 1906

PUBLISHED BY ORDER OF THE EXECUTIVE COMMITTEE

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PROPOSED CHANGES IN THE STATUTES AND STANDING VOTES OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES.

CHAPTER I.

Sect. 1. "Theology" inserted before "Philosophy" in Class III. Sect. 1.

CHAPTER II.

Sect. 2. The Chairmen of the Rumford, C. M. Warren, and Publication Committees are made members of the Council, in place of three Vice-Presidents.

Sect. 3. New Section in regard to appropriations.

Sect. 4. The same as the old Section 3 with the word "and" omitted in line 2.

CHAPTER III.

No change except omit in Section 1 the restriction by which the Nominating Committee is to be formed "from the next retiring Councillors." Committee to be of Resident Fellows.

CHAPTER IV.

Sect. 1. No change except the phrase about calling special meetings.

Sect. 2. Omitted. The approval and payment of bills provided for by this section is now provided for elsewhere.

Sect. 2. Same as old Section 3.

Sect. 3. Same as old Section 4.

CHAPTER V.

Sect. 2. Finance Committee. No change except omitting appropriations, which are provided for elsewhere.

Sect. 3. Rumford Committee. The new section includes provision for approval of bills, etc.

Sect. 4. C. M. Warren Committee. (The same as Section 3).

Sect. 5. Committee on Publication. (The same as Section 3).

Sect. 6. Committee on Library. Added provision for approval of bills, etc.

Sect. 7. President and Recording Secretary made a Committee on general appropriations with power to approve bills.

Sect. 8. Auditing Committee. Power to employ an expert now added.

Sect. 9. Authorizes Chairmen of Committees to appoint member of Committee to approve bills.

CHAPTER VI.

Sect. 1. Merely verbal changes.

Sect. 4. Added. Require receipts to be taken for papers, etc., taken from the Records.

CHAPTER VII.

Sect. 2. Authorizing the payment by Treasurer of bills when approved by proper officers, and the Treasurer's right to approve bills in his own office. Giving the Treasurer power to sign leases. Transfer of stocks to be made by Treasurer with written consent of one member of Committee of Finance.

Sect. 4. Omit old Section 4 and make a new Section 4 the same as present Section 5.

CHAPTER VIII.

Sect 2, line 4. Add "periodicals, etc.," after "books."

Sect. 7. Distribution of publications provided for in Standing Vote 2.

CHAPTER IX.

Sect. 1. Provision made for doing any act at a special meeting called for the purpose and for calling special meetings.

Sect. 2, line 2. Add "or special" after the word "stated." Confining business to Resident Fellows.

Sect. 3. Confining business to Resident Fellows and omitting "residing in Boston and the vicinity."

CHAPTER X.

Sect. 2. Nomination of the Council need not have the *written* approval of members, and all nominations may be read at any meeting of the Academy, and must stand on the nomination list until the next stated meeting.

New paragraph for equalizing the number of Resident Fellows in the three classes.

Sect. 6. Omitted.

CHAPTER XI.

No change except in regard to allowing business to be transacted at a special meeting called for the purpose instead of at a stated meeting.

STANDING VOTES.

Sect. 2. New section for Distribution of Publications.

Sect. 8. The approval of a bill by the Chairman of the Rumford Committee shall be proof to the Treasurer that the certificate of the Committee has been given to the purchase of books, etc., as required by this section.

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VOLUME I

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AUTHORS' INDEX

WITH SYNOPSES OF PAPERS

of co-operative relations, both moral and financial, among the different electrical interests, from the manufacturer to the consumer, to the end that each may contribute in some measure toward bringing about the above results desired in common by all. Mr. Crouse details the methods by which these are to be obtained.
Discussion by Marsh, Gilchrist. 352 to 374, 379 to 381.

DICKINSON, W. N., JR. *Alternating-Current Elevators:* Paper opens with possible type of electrically driven elevators, but deals principally with direct-connected types. A brief description of the earlier forms of induction-motor elevators follows, bearing principally on forms of control, especially in reference to alternating-current magnets. Faults also considered. Reference made to Professor Sever's investigations. Difficulties impeding development of direct-connected alternating-current elevators are discussed in detail. The requirements for a successful motor and a successful method of control, together with the approach of existing machines and methods of control to these requirements, are next taken up, and followed by a thorough discussion of requirements for safety, and how such requirements may be met. A comparison of single-phase and multiphase machines follows. Paper ends with present successful methods of control.
Discussion by Wagoner, McCabe, Layman. 466 to 482.

DOW, ALEX. *Report on Protection from Lightning During 1905:* Paper opens with methods employed for compiling report, and gives full statistics on results and ends with conclusions derived therefrom. Injuries to arresters, transformers, meters, and armatures are discussed in detail, for both large and small plants, and for different voltages used by them. The causes of these injuries and methods of avoiding their recurrence follow.
Discussion by Neall, Wirt. 382 to 395.

EGLIN, W. C. L. *Report of the Committee for the Investigation of the Steam Turbine:* The committee visited the works of the manufacturers of the various types of turbines and report embodies the result of their observations and discussions with the engineers of the manufacturing companies concerning the turbines built by them. The steam turbine now recognized as a standard piece of apparatus and turbines of some type are being installed in nearly all the newer power-houses. They are also successfully introduced into the merchant marine and have been approved by the British navy commission for use in battleships. No radical changes have been made in the design of the turbine itself, the tendency being more toward improvement of the revolving-field generator, blade construction and valve gear. Mention is made of the double-flow type of turbine being built by the Westinghouse Company. The committee reports on the following turbines and works: Curtis turbine, General Electric Company, Schenectady and Lynn Works; Westinghouse-Parsons turbine, Westinghouse Machine Company, Pittsburgh; Allis-Chalmers turbine, Allis-Chalmers Company, Milwaukee, Wis. Paper is illustrated by cuts and diagrams of the turbines and important parts. Lists are also appended giving names of purchasers and sizes of turbines installed or in construction. Mr. I. E. Moultrop, one of the members of the committee, visited Europe to investigate turbine developments abroad, and his report will be found under his name. 87 to 124.

FRUEAUFF, FRANK W. *Business-Getting Methods:* According to Mr. Frueauff, the best results are secured through systematic solicitation followed up and interwoven with general and personal advertising. So-

licitors must be thoroughly drilled in their work, and still better, have the assistance of specialists, as illuminating engineers, etc. One of the most important features of getting new business is in the persistency that is used. Most orders are obtained after three or four visits. Judicious and attractive advertising and special letter writing will cut down the number of visits otherwise necessary. Complaints should be given careful attention and a friendly feeling established with customers. Careful records of work done by representatives should be kept. The force of example is commended; the company itself should be foremost in the liberal use of current and its office or plant made a convincing proof of the efficacy of display lighting. 257 to 265, 307 to 315.

GILCHRIST, JOHN F. *Electric Signs—Their Free Installation as a Factor in Central-Station Prosperity, and a Report of Electric-Sign Conditions in the United States:* This paper is an extensive report on the electric-sign business in the United States. Lists of questions were sent to 3300 central stations for data, of which 1188 were filled out and returned. The conclusions given are based mainly upon these answers, supplemented by the writer's own knowledge of the field and conditions. The sign business is one of the most desirable sources of revenue and, more than any other, warrants encouragement. The greatest success has been met with "Free Signs." The success or failure of the sign business depends upon the methods used in putting the matter before the merchants and upon the subsequent "Sign Service." Some central stations rely entirely on a canvass, others on an advertising campaign: the best results are obtained from use of both. Where harmful ordinances and unfavorable councils are encountered it need only be shown what is being done in other cities, and benefits derived, for the passage of favorable ordinances. Reproductions of photographs of different types of signs show to what varied uses they can be applied. The statistics collected are given in table form, arranged according to population of cities. Appended is an outline ordinance, also a specimen contract.

No discussion. 318 to 351.

HALLBERG, HENRY J. *Fuel Economy:* A description of the Arndt Automatic Company's recorder, a device which automatically analyzes the amount of carbon dioxide in the flue gases and records readings of same on a chart. This shows the stoker the state of the combustion in his furnace and so tends to insure highest combustion of fuel and resultant economy of operation of the boilers. The record also enables the person in charge to see at what efficiency the plant is running and the skill of the different stokers, and in case of strike is a great help to inexperienced employees. The principle of the recorder is based on the fact that a potash solution absorbs carbonic-acid gas. The apparatus is absolutely automatic, makes analyses every five to seven minutes and does not easily get out of order. It can be used for several furnaces, is not expensive when the saving entailed is considered, and needs but one renewal of potash a week. Illustrated by diagrams and cuts.

Discussion by Claflin, Nash, Campbell. 180 to 191.

HEWLETT, E. M. *Modern Switchboard Practice, with Particular Reference to Automatic Devices:* After advocating simplicity, writer discusses various devices used. (1) Oil switches are first considered. These are divided into three classes, for three different kinds of services, and discussed separately—small, medium and large. Method of control and mounting of switches considered for each case, as well as mechani-

cal devices used. (2) The relay is next taken up, and divided into four different types. Expulsion fuse discussed, and followed by discussion of four systems of alternating-current distribution in detail. Paper illustrated with photographs and diagrams.
Discussion by Wallau. 485 to 509.

Hosmer, Sidney. *Grounding Secondary Alternating-Current Services:* Paper gives brief history of attempt of Boston Edison Company to establish a standard method for grounding secondary alternating-current circuits. The impracticability of grounding at the transformer is discussed, and is followed by a set of requirements made for grounding individual services to water pipes. Difficulties encountered in carrying out said rules, especially with water companies, closes the paper.
Discussion by Bartlett, Morrison. 396 to 401.

James, H. D. *Control of Motors on Electric Light and Power Circuits:* Paper discusses Rheostatic, Voltage, Change of Motor Characteristics, Mechanical and Brake Control for both alternating-current and direct-current motors, and ends with applications. Subjects are thoroughly treated. Illustrated by diagrams.
No discussion. 510 to 534.

Marks, Louis B. *The Flaming Carbon Arc Lamp* (With Special Reference to Its Adaptability to Street Illumination in the United States): Mr. Marks' paper compares the enclosed-arc lamp and flaming-arc lamp, particularly as regards suitability for street lighting. By means of tables and charts he shows cost of operation per lamp for various costs of energy and of carbons. The conclusions arrived at by the author are that a flaming-arc lamp will give five times the illumination of an enclosed arc consuming the same energy, yet owing to the disadvantageous distribution of the illumination only two enclosed arcs can be replaced by one flaming arc. Frequent trimmings with expensive carbons far offset the advantage of economical production of light. The fumes and ashes given out by the lamp and the unsteadiness of the light make the lamp unsuitable for interior illumination. Abroad, especially in London, Paris and Berlin, it is meeting with extensive favor, being extensively used in prominent streets. This is no doubt due to conditions there; the cost of energy being much higher and cost of labor lower than in this country; the price of carbons is also very much lower. Under these conditions the charts and tables show the flaming arc to compare favorably in cost with the enclosed arc, having in addition, the warm and penetrating light of the latter. Paper is illustrated by cuts of various parts of the lamps, photographic reproduction of the flaming arc and tables and charts giving data under various conditions.
Discussion by Wagoner, Hallberg, Perkins, Barstow, Williams, the President, Scovil, Auerbacher, Rhodes. 64 to 85, 252 to 254.

Martin, T. C. The report deals with the conditions of the art during the past year. Included are also some new statistics on electric light and power apparatus for 1904, just published by the United States Census Bureau. The committee has treated the subject under the following seventeen heads: Domestic Statistics; Foreign Data; New Central-Station Work; Central-Station Employees; Joint Operation of Pole Lines; Rules for Wiring; Old and New Illuminants; Use of the Nernst Lamps; Progress of the Luminous Arc; Small Carbons and Small Arc Lamps; Vapor Lamps; Incandescent Lamps; Rates and Meters; Protection Against Swindles; State Lighting Commissions; Standardizing Electric Machinery. 10 to 53.

SCHERCK, LEON H. *Some Methods Used in Securing and Retaining Business:* Paper is divided into two parts. Under Business-Getting are the following headings: Organization of a Contract Department; House-to-House Canvass; Regarding Large Power Business; Free Signs; Free Wiring; Renting of Fans; Information Card; Enlisting the Aid of School Children. Under Retaining Business we have: Good Service; An Effective Meter Department; Avoid Special Rates; Study Your Rates; Liberality; Prompt Attention; Politeness. A specimen contract for sign service is given, also specimen filing cards, and copy of an ordinance and amendment regulating the erection and maintenance of signs along streets. 293 to 315.

SPENCER, PAUL. *Report of Committee to Co-operate with Manufacturers' Advertising Committee:* The committee reports on the relations of the association with the Co-operative Electrical Development Association, the plan of work and proposed future development of same being described in detail by Mr. Crouse in his paper, *Profitable Commercial Co-operation.*
Discussion by Selig, Marsh, Gilchrist. 375 to 381.

Line Construction for Overhead Light and Power Service: According to the author the electric light and power system can be broadly divided into three parts: The generation, the distribution, and the utilization of the current. The progress made in the first and last has been constant and rapid, but the distribution of the current from the power station to the consumer has received much less attention. The general belief that overhead service is much more unreliable than underground service is due to the generally poor construction of overhead lines throughout the country. Considering electric light companies as a whole, the largest extent of the territory covered must be reached by overhead lines. The points to be considered in line construction in order of their importance are: (1) The safety of the public and company's employees; (2) Reliability of the company's service; (3) Sightliness of construction. Mr. Spencer quotes at length from the line specifications recently prepared for the electric companies of the United Gas Improvement Company and of the Public Service Corporation of New Jersey. Paper is illustrated by the company's standard drawings.
Discussion by Mordock, Partridge, Rhodes, McCabe, Lloyd, Morrison, Wells, Hutchinson. 207 to 252.

STONE, CHARLES W. *Alternating-Current Systems of Distribution and Their Automatic Regulation:* Subject is divided principally into discussion of primary and secondary distribution and methods of regulation. Under Primary Distribution the relative merits of single-phase, two-phase, three-wire; two-phase, four wire; three-phase, four-wire, and three-phase, three-wire are taken up in detail. Under Secondary Distribution the three-wire system is largely discussed. Under Regulation, automatic regulators for operating directly or indirectly to change potential of generator and for operating directly on the feeders are discussed in detail, the Tirrill regulator being especially considered. Paper illustrated with photographs and diagrams.
Discussion by Wallau, Hallberg, Geiser. 424 to 449.

STOY, HON. F. P., Mayor of Atlantic City. *Address of Welcome:* Extends hearty welcome to the members and also freedom of the city. 2, 3.

TIDD, GEO. N. *Some Methods Used in Securing and Retaining Business:* Some of the methods used by the writer which have been productive

of results are: Circular personal letters sent to business houses, factories and residences at least once a month, and, if after a few months no response is met with, a personal call made by solicitor. Newspaper advertising, which is most helpful and effective among merchants who themselves advertise and scrutinize all advertisements. A display-room or attractive show-window. Installation of various devices upon two or three weeks' trial. Installation of motors in factories on trial. Various forms of contract which will allow the development of long-hour business for light and power. Old business retained by sparing no effort in keeping customers satisfied. Complaints are immediately thoroughly investigated. Utmost tact is used in treating dissatisfied customers, and most complaints are anticipated by having solicitors call on customers to see if they are getting satisfactory results. 279 to 281, 307 to 315.

TRIPP, GEO. B. *Some Methods Used in Securing and Retaining Business:* Author describes business-getting methods employed at Colorado Springs. Paper is divided into two parts: Getting New Business and How to Retain Profitable Business. A business department should be instituted with manager in charge; the city divided into districts and a solicitor detailed for each. Their work should be augmented by judicious advertising and "follow-up" letters. The sign business mentioned as one of the most profitable, and very remunerative to the company. Under retaining profitable old business the author states that the rates for service must be as low as possible. The service must be maintained at the highest standard. Every consumer should be made to feel that his business is wanted by the company. Public-service corporations should deal with the general public and municipality from the stand that they have nothing to conceal. Reduce rates when earnings warrant. 289 to 293, 307 to 315.

TURNER, MATHIAS E. *Some Methods Used in Securing and Retaining Business:* Mr. Turner briefly touches on some of the methods that have been especially successful in Cleveland. He divides business into three classes: (1) That of securing as patrons tenants of newly-erected buildings; (2) That of introducing electricity where other illuminants or modes of power are exclusively used: (3) That of increasing the use of electricity where it and competitive means of light and power are used. The sales department should have its efforts complemented by the work of illuminating and mechanical engineers who make a study of illumination and power economies, who keep posted on the newest and best in their line, who are thorough and practical wiremen and who can estimate closely on cost of work. Advertising and follow-up systems also bring results from proper fields. To retain business demands careful watch of customers' accounts, and continual investigation of their electrical installation. 275 to 277, 307 to 315.

WALLACE, R. S. *Some Methods Used in Securing and Retaining Business:* Mr. Wallace discusses business-getting under the following headings: Solicitors; Co-operation with Employees; Salesroom; Catalogues; Appliances; Policy; New-Business Index; Publicity; Cultivating Popularity; Newspaper Advertising; Mail Campaigns; Co-operation with Contractors. 285 to 289, 307 to 315.

WILCOX, NORMAN T. *Some Methods Used in Securing and Retaining Business:* Mr. Wilcox takes men who are ambitious and willing from the operating force, gives them a definite district to work in, equips

GENERAL INDEX

PROCEEDINGS OF THE TWENTY-NINTH CONVENTION

NOTE.—Authors' names will be found in the authors' index, as also briefs of the papers and reports presented. Reports of committees are under the chairman's name.

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CONVENTIONS OF THE ASSOCIATION

First	Chicago, February 25, 26, 1885
Second	New York, August 18, 19, 20, 1885
Third	Baltimore, February 10, 11, 12, 1886
Fourth	Detroit, August 31, September 1, 2, 1886
Fifth	Philadelphia, February 15, 16, 17, 1887
Sixth	Boston, August 9, 10, 11, 1887
Seventh	Pittsburgh, February 21, 22, 23, 1888
Eighth	New York, August 29, 30, 31, 1888
Ninth	Chicago, February 19, 20, 21, 1889
Tenth	Niagara Falls, August 6, 7, 8, 1889
Eleventh	Kansas City, February 11, 12, 13, 14, 1890
Twelfth	Cape May, August 19, 20, 21, 1890
Thirteenth	Providence, February 17, 18, 19, 1891
Fourteenth	Montreal, September 7, 8, 9, 10, 1891
Fifteenth	Buffalo, February 23, 24, 25, 1892
Sixteenth	St. Louis, February 28, March 1, 2, 1893
Seventeenth	Washington, February 27, 28, March 1, 2, 1894
Eighteenth	Cleveland, February 19, 20, 21, 1895
Nineteenth	New York, May 5, 6, 7, 1896
Twentieth	Niagara Falls, June 8, 9, 10, 1897
Twenty-first	Chicago, June 7, 8, 9, 1898
Twenty-second	New York, May 23, 24, 25, 1899
Twenty-third	Chicago, May 22, 23, 24, 1900
Twenty-fourth	Niagara Falls, May 21, 22, 23, 1901
Twenty-fifth	Cincinnati, May 20, 21, 22, 1902
Twenty-sixth	Chicago, May 26, 27, 28, 1903
Twenty-seventh	Boston, May 24, 25, 26, 1904
Twenty-eighth	Denver-Colorado Springs, June 6, 7, 8, 9, 10, 11, 1905
Twenty-ninth	Atlantic City, June 5, 6, 7, 8, 1906

PRESIDENTS OF THE ASSOCIATION

James F. Morrison, of Baltimore
Samuel A. Duncan, of Pittsburgh
Edwin R. Weeks, of Kansas City
Marsden J. Perry, of Providence
Charles R. Huntley, of Buffalo
James I. Ayer, of St. Louis
Edward A. Armstrong, of Camden
M. Judson Francisco, of Rutland
C. H. Wilmerding, of Chicago
Frederic Nicholls, of Toronto
Samuel Insull, of Chicago
Alden M. Young, of Waterbury
Samuel T. Carnes, of Memphis
James Blake Cahoon, of New York
Henry L. Doherty, of Denver
Louis A. Ferguson, of Chicago
Charles L. Edgar, of Boston
Ernest H. Davis, of Williamsport
Wm. H. Blood, Jr., of Boston

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Marcel Deprez, Paris, France
George D. Forbes, London, England
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*Z. T. Gramme, Paris, France
*Dr. John Hopkinson, London, England
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*Sir William Dawson, Montreal, Canada
Frank R. Redpath, Montreal, Canada
Prof. Henry T. Bovey, McGill University, Montreal, Canada
Thomas D. Lockwood, Boston, Massachusetts
Nikola Tesla, New York City
James I. Ayer, Boston, Massachusetts
Cyrus O. Baker, Jr., New York City
Frederic Nicholls, Toronto, Canada

* Deceased

MEMBER COMPANIES—CLASS A

ALABAMA

ANNISTON,	Anniston Electric and Gas Company
BIRMINGHAM,	Birmingham Railway, Light and Power Company
DEMOPOLIS,	Demopolis Electric Light and Power Company
MOBILE,	Mobile Light and Railroad Company
MONTGOMERY,	Montgomery Light and Water Power Company

ARIZONA

MESA,	Mesa Light and Power Company
PHŒNIX,	Phœnix Light and Fuel Company
PRESCOTT,	The Prescott Electric Company
TUCSON,	The Tucson Gas, Electric Light and Power Company

ARKANSAS

EUREKA SPRINGS,	Citizens' Electric Company
FORT SMITH,	Fort Smith Light and Traction Company
HOT SPRINGS,	Hot Springs Water Company
LITTLE ROCK,	Little Rock Railway and Electric Company
PINE BLUFF,	Pine Bluff Light and Water Company
TEXARKANA,	Texarkana Gas and Electric Company

CALIFORNIA

EUREKA,	Eureka Lighting Company
FORTUNA,	Fortuna Lighting Company
LOS ANGELES,	Los Angeles Gas and Electric Company
	Pacific Light and Power Company
	The Edison Electric Company
MARYSVILLE,	Marysville Gas and Electric Company
MONTEREY,	Monterey County Gas and Electric Company
OAKLAND,	Oakland Gas, Light and Heat Company
ONTARIO,	Ontario Power Company
OROVILLE,	Oroville Light and Power Company
OXNARD,	Ventura County Power Company
SACRAMENTO,	Sacramento Electric, Gas and Railway Company
SAN FRANCISCO,	San Francisco Gas and Electric Company
SAN LEANDRO,	Suburban Electric Light Company
SONORA,	Tuolumne County Electric Power and Light Company
STOCKTON,	Stockton Gas and Electric Company
VENTURA,	Ventura County Power Company
VISALIA,	Mt. Whitney Power Company

COLORADO

Aspen,	The Roaring Fork Electric Light and Power Company
Boulder,	The Boulder Electric Light and Power Company
Cañon City,	Colorado Light and Power Company
Colorado Springs,	The Colorado Springs Electric Company
Denver,	The Denver Gas and Electric Company
	The Mountain Electric Company
Durango,	Durango Light and Power Company
Fort Collins,	The Larimer Light and Power Company
Georgetown,	The United Hydro-Electric Company
Golden,	The Golden Illuminating Company
Grand Junction,	Grand Junction Electric and Gas Company
Idaho Springs,	The Consolidated Gem Mines Company
Las Animas,	Las Animas Electric Company
Leadville,	Leadville Gas and Electric Company
Littleton,	The Arapahoe Electric Light and Power Company
Louisville,	Consumers' Electric Company
Ouray,	The Ouray Electric Power and Light Company
Pueblo,	The Pueblo and Suburban Traction and Lighting Company
Telluride,	The Telluride Electric Light and Power Company
	The Telluride Power Company

CONNECTICUT

Branford,	Branford Lighting and Water Company
Bridgeport,	Connecticut Railway and Lighting Company
Danbury,	Danbury and Bethel Gas and Electric Light Company
Danielson,	People's Light and Power Company
Derby,	Derby Gas Company
Hartford,	The Hartford Electric Light Company
Litchfield,	The Litchfield Electric Light and Power Company
Meriden,	Meriden Electric Light Company
New Haven,	The United Illuminating Company
New London,	New London Gas and Electric Company
Rockville,	The Rockville Gas and Electric Company
South Manchester,	South Manchester Light, Power and Tramway Company
Stamford,	The Stamford Gas and Electric Company
Suffield,	Village Water Company
Thompsonville,	Enfield Electric Light and Power Company
Unionville,	The Union Electric Light and Power Company
Westport,	The Westport Water Company

DELAWARE

Wilmington,	The Wilmington City Electric Company

DISTRICT OF COLUMBIA

WASHINGTON,	Potomac Electric Power Company

FLORIDA

KEY WEST,	The Key West Electric Company
PENSACOLA,	Escambia County Electric Light and Power Company
TAMPA,	Tampa Electric Company

GEORGIA

ALBANY,	Albany Power and Manufacturing Company
ATHENS,	Athens Electric Railway Company
ATLANTA,	Georgia Railway and Electric Company
AUGUSTA,	Augusta Railway and Electric Company
COLUMBUS,	Columbus Railroad Company
GAINESVILLE,	North Georgia Electric Company
SAVANNAH,	Savannah Electric Company

HAWAII

HILO,	Hilo Electric Light Company, Limited
HONOLULU,	Hawaiian Electric Company, Limited

IDAHO

BOISE,	Capital Electric Light, Motor and Gas Company
	Electric Power Company, Limited
DEWEY,	Trade Dollar Consolidated Mining Company
LEWISTON,	Lewiston-Clarkston Company
MOSCOW,	Moscow Electric Light and Power Company
POCATELLO,	American Falls Power, Light and Water Company

ILLINOIS

ABINGDON,	Abingdon Electric Company
ALTON,	Alton Gas and Electric Company
BEARDSTOWN,	Beardstown Electric Light and Power Company
BLOOMINGTON,	Bloomington and Normal Railway and Light Company
CANTON,	People's Gas and Electric Light Company
CENTRALIA,	Centralia Gas and Electric Company
CHICAGO,	Chicago Edison Company
	Chicago Sectional Electric Underground Company
	Commonwealth Electric Company
CLINTON,	Clinton Gas Company
DEKALB,	DeKalb-Sycamore Electric Company
DIXON,	Lee County Lighting Company
EDWARDSVILLE,	Edwardsville Electric Light and Power Company
EVANSTON,	North Shore Electric Company
FREEPORT,	Freeport Railway, Light and Power Company

ILLINOIS—*Continued*

HILLSBORO,	Hillsboro Electric Light and Power Company
JOLIET,	Economy Light and Power Company
MOLINE,	People's Power Company
MT. CARMEL,	The New Electric Company
NOKOMIS,	Nokomis Electric Light and Power Company
OAK PARK,	Oak Park Yaryan Company
PEORIA,	Peoria Gas and Electric Company
PONTIAC,	Pontiac Light and Water Company
QUINCY,	Quincy Gas, Electric and Heating Company
ROCKFORD,	Rockford Edison Company
SPRINGFIELD,	Springfield Light, Heat and Power Company
TAYLORVILLE,	Taylorville Electric Plant
WARSAW,	Warsaw Electric Plant
WATSEKA,	Watseka Electric and Heat Company

INDIANA

ELKHART,	Elkhart Electric Company
ELWOOD,	Elwood Electric Light Company
EVANSVILLE,	Evansville Gas and Electric Light Company
FORT WAYNE,	Fort Wayne and Wabash Valley Traction Company
GOSHEN,	The Hawks Electric Company
KOKOMO,	Kokomo, Marion and Western Traction Company
MARION,	Marion Light and Heating Company
NEW ALBANY,	United Gas and Electric Company
RICHMOND,	Richmond Light, Heat and Power Company
SOUTH BEND,	South Bend Electric Company
TERRE HAUTE,	Terre Haute Traction and Light Company
WABASH,	Wabash Water and Light Company

INDIAN TERRITORY

SOUTH MCALESTER,	Choctaw Electric Company

IOWA

CEDAR RAPIDS,	Cedar Rapids and Iowa City Railway and Light Company
CLARINDA,	Lee Electric Light Company
CORNING,	Corning Light, Heat and Power Company
DAVENPORT,	People's Light Company
DECORAH,	The Decorah Electric Light Company
DES MOINES,	Des Moines Edison Light Company
DUBUQUE,	Union Electric Company
IOWA CITY,	Iowa City Electric Light Company
KEOKUK,	Keokuk Electric Railway and Power Company
MASON CITY,	Brice Gas and Electric Company
OTTUMWA,	Ottumwa Traction and Light Company

IOWA *Continued*

Red Oak,	Red Oak Electric Company
Sioux City,	Sioux City Gas and Electric Company
	Sioux City Service Company
Waterloo,	Waterloo and Cedar Falls Gas and Electric Light Company

KANSAS

Abilene,	The Riverside Light and Power Company
Beloit,	Beloit Light and Water Company
Clay Center,	F. L. Williamson and Company
Columbus,	The Columbus Electric Company
Holton,	Holton Electric Company
Hutchinson,	The Water, Light and Gas Company
Junction City,	The Electric Railway, Light and Ice Company
Leavenworth,	Leavenworth Light and Heating Company
Topeka,	The Topeka Edison Company

KENTUCKY

Covington,	Union Light, Heat and Power Company
Lexington,	Lexington Railway Company
Louisville,	Louisville Lighting Company
Paducah,	The Paducah Light and Power Company

LOUISIANA

Baton Rouge,	Baton Rouge Electric and Gas Company
Lake Charles,	The Lake Charles Ice, Light and Water Works Company
New Orleans,	New Orleans and Carrollton Railroad, Light and Power Company
Shreveport,	Shreveport Gas, Electric Light and Power Company

MAINE

Auburn,	The Lewiston and Auburn Electric Light Company
Bangor,	Bangor Railway and Electric Company
Brunswick,	Brunswick Electric Light and Power Company
Caribou,	Caribou Water, Light and Power Company
Kezar Falls,	Cornish and Kezar Falls Light and Power Company
Portland,	Consolidated Electric Light Company of Maine
	Portland Lighting and Power Company
Rumford Falls,	Rumford Falls Light and Power Company
Skowhegan,	Skowhegan Electric Light Company
Waterville,	The Messalonskee Electric Company
	Waterville and Fairfield Railway and Light Company

MARYLAND

Baltimore,	Consolidated Gas, Electric Light and Power Company
Crisfield,	Crisfield Ice Manufacturing Company
Frederick,	Frederick Gas and Electric Company
Havre de Grace,	The Havre de Grace Electric Company
Highlandtown,	The Baltimore County Water and Electric Company

MASSACHUSETTS

Amherst,	Amherst Gas Company
Attleboro,	Attleboro Steam and Electric Company
Beverly,	Beverly Gas and Electric Company
Boston,	Boston Consolidated Gas Company
	Edison Electric Illuminating Company of Boston
Brockton,	Edison Electric Illuminating Company of Brockton
Cambridge,	Cambridge Electric Light Company
Chelsea,	Chelsea Gas Light Company
Clinton,	Clinton Gas Light Company
Cohasset,	The Cohasset Electric Company
Fall River,	Fall River Electric Light Company
Fitchburg,	Fitchburg Gas and Electric Light Company
Gardner,	Gardner Electric Light Company
Great Barrington,	Great Barrington Electric Light Company
Greenfield,	Greenfield Electric Light and Power Company
Haverhill,	Haverhill Electric Company
Hyde Park,	Hyde Park Electric Light Company
Lawrence,	Lawrence Gas Company
Lee,	Lee Electric Company
Leicester,	Rawson Light and Power Company
Lexington,	Lexington Gas and Electric Company
Lowell,	The Lowell Electric Light Corporation
Lynn,	Lynn Gas and Electric Company
Malden,	Malden Electric Company
Marlborough,	Marlborough Electric Company
New Bedford,	New Bedford Gas and Edison Light Company
Newton,	Newton and Watertown Gas Light Company
North Adams,	North Adams Gas Light Company
Palmer,	Central Massachusetts Electric Company
Pittsfield,	Pittsfield Electric Company
Plymouth,	Plymouth Electric Light Company
Revere,	Suburban Gas and Electric Company
Salem,	Salem Electric Lighting Company
Southbridge,	Southbridge Gas and Electric Company
Springfield,	United Electric Light Company
Webster,	Webster Electric Company
Westboro,	Westboro Gas and Electric Company
Winchendon,	Winchendon Electric Light and Power Company
Woburn,	Woburn Light, Heat and Power Company
Worcester,	Worcester Electric Light Company

MICHIGAN

ADRIAN,	Citizens' Light and Power Company
ANN ARBOR,	Washtenaw Light and Power Company
BIG RAPIDS,	W. E. Donley Electric Light and Power Company
BROOKLYN,	L. W. Greene
CHEBOYGAN,	Cheboygan Electric Light and Power Company
CONSTANTINE,	Constantine Hydraulic Company
CORUNNA,	Shiawassee Light and Power Company
DETROIT,	Peninsular Electric Light Company
HOUGHTON,	Houghton County Electric Light Company
IONIA,	Ionia Water Power Electric Company
ISHPEMING,	Marquette County Gas, Light and Traction Company
JACKSON,	Commonwealth Power Company
LUDINGTON,	The Stearns Lighting and Power Company
MANISTIQUE,	Manistique Light and Power Company
MUSKEGON,	Muskegon Traction and Lighting Company
OWOSSO,	Owosso and Corunna Electric Company
PLAINWELL,	Brownell Electric Company
PORT HURON,	Port Huron Light and Power Company
SAGINAW,	Bartlett Illuminating Company
ST. JOSEPH,	Benton Harbor and St. Joseph Electric Railway and Light Company
SAULT STE. MARIE,	Edison Sault Electric Company

MINNESOTA

ALBERT LEA,	Albert Lea Light and Power Company
CROOKSTON,	Crookston Water Works, Power and Light Company
DULUTH,	Duluth Edison Electric Company
FARIBAULT,	The Faribault Gas and Electric Company
LITTLE FALLS,	The Little Falls Water Power Company of Minnesota
MINNEAPOLIS,	The Minneapolis General Electric Company
MONTEVIDEO,	The Montevideo Electric Light and Power Company
PIPESTONE,	Pipestone Electric Light, Heat and Power Company
RED WING,	Red Wing Gas Light and Power Company
ST. CLOUD,	The Public Service Company of St. Cloud
ST. PAUL,	Edison Electric Light and Power Company
WINONA,	Winona Railway and Light Company

MISSISSIPPI

HATTIESBURG,	Hattiesburg Light and Power Company
JACKSON,	Jackson Gas Light Company
LAUREL,	Gulf States Investment Company
McCOMB CITY,	McComb City Electric Light and Power Company
MERIDIAN,	Meridian Light and Railway Company
NATCHEZ,	Southern Light and Traction Company
VICKSBURG,	Vicksburg Railway and Light Company

MISSOURI

DE SOTO,	Consumers' Electric Light and Power Company
EXCELSIOR SPRINGS,	The Excelsior Springs Light, Power, Heat and Water Company
KANSAS CITY,	Kansas City Electric Light Company
ST. JOSEPH,	St. Joseph Railway, Light, Heat and Power Company
ST. LOUIS,	The Laclede Gas Light Company
	The Laclede Power Company of St. Louis
	Union Electric Light and Power Company
SPRINGFIELD,	Springfield Gas and Electric Company
TRENTON,	Trenton Gas, Light and Power Company
WASHINGTON,	Tibbe Electric Company

MONTANA

ANACONDA,	The Anaconda Copper Mining Company, Electric Light Department
BILLINGS,	Billings Water Power Company
BUTTE,	Butte Electric and Power Company
GREAT FALLS,	Great Falls Electric Properties
HELENA,	Helena Light and Railway Company
KALISPELL,	Big Fork Electric Power and Light Company
MISSOULA,	Missoula Light and Water Company

NEBRASKA

BEATRICE,	Beatrice Electric Company
BLAIR,	Blair Electric Light and Power Company
GRAND ISLAND,	Grand Island Electric Company
KEARNEY,	The Northwestern Electric, Heat and Power Company
LEXINGTON,	Lexington Mill and Elevator Company
LINCOLN,	Lincoln Gas and Electric Company
OMAHA,	Omaha Electric Light and Power Company

NEVADA

RENO,	Truckee River General Electric Company

NEW HAMPSHIRE

CONCORD,	Concord Electric Company
DOVER,	Dover Gas Light Company
FRANKLIN FALLS,	The Franklin Light and Power Company
KEENE,	Keene Gas and Electric Company
MANCHESTER,	Manchester Traction, Light and Power Company
NASHUA,	Nashua Light, Heat and Power Company
NEWPORT,	Newport Electric Light Company
PENACOOK,	Penacook Electric Light Company
PORTSMOUTH,	Rockingham County Light and Power Company

NEW JERSEY

Atlantic City,	The Atlantic Electric Light and Power Company
Bridgeton,	Bridgeton Electric Company
Dover,	Dover Electric Light Company
Egg Harbor City,	Atlantic County Electric Company
Hammonton,	Hammonton Electric Light Company
Lambertville,	Lambertville Heat, Light and Power Company
Long Branch,	Consolidated Gas Company of New Jersey
Millville,	Millville Electric Light Company
Newark,	Public Service Corporation of New Jersey
Summit,	Commonwealth Water and Light Company

NEW MEXICO

Albuquerque,	Albuquerque Gas, Electric Light and Power Company
Las Vegas,	Las Vegas Light and Fuel Company

NEW YORK

Albany,	Hudson River Electric Power Company
Albion,	Albion Power Company
Amsterdam,	Edison Electric Light and Power Company
Auburn,	Auburn Light, Heat and Power Company
Binghamton,	Binghamton Light, Heat and Power Company
Brooklyn,	Edison Electric Illuminating Company of Brooklyn
Buffalo,	Buffalo General Electric Company
	Niagara, Lockport and Ontario Power Company
	The Cataract Power and Conduit Company
Cazenovia,	Union Electric Company
Cooperstown,	Clinton Mills Power Company
Cortland,	Cortland County Traction Company
Dundee,	Dundee Electric Lighting Plant
Elmira,	Elmira Water, Light and Railroad Company
Far Rockaway,	Queens Borough Gas and Electric Company
Fishkill-on-Hudson	Southern Dutchess Gas and Electric Company
Fulton,	Fulton Light, Heat and Power Company
Gloversville,	Fulton County Gas and Electric Company
Greenwich,	Consolidated Electric Company
Hoosick Falls,	Hoosick Falls Illuminating Company
Ithaca,	Ithaca Electric Light and Power Company
Jamestown,	Jamestown Lighting and Power Company
Keeseville,	Keeseville Electric Company
Kingston,	Kingston Gas and Electric Company
Liberty,	The Liberty Light and Power Company
Little Falls,	Herkimer County Light and Power Company
Lockport,	Economy Light, Fuel and Power Company
	Lockport Gas and Electric Light Company
Long Island City,	New York and Queens Electric Light and Power Company

NEW YORK—*Continued*

Lyons,	Wayne County Electric Company
Middletown,	Orange County Lighting Company
Mount Vernon,	Westchester Lighting Company
New Brighton,	Richmond Light and Railroad Company
Newburgh,	Newburgh Light, Heat and Power Company
New York City,	The New York Edison Company
	The United Electric Light and Power Company
Niagara Falls,	Buffalo and Niagara Falls Electric Light and Power Company
	Niagara Falls Hydraulic Power and Manufacturing Company
	The Niagara Falls Power Company
North Tonawanda,	Tonawanda Power Company
Norwich,	The Norwich Gas and Electric Company
Nyack,	Rockland Light and Power Company
Oneida,	Madison County Gas and Electric Company
Oneonta,	Oneonta Light and Power Company
Ossining,	Northern Westchester Lighting Company
Ovid,	Ovid Electric Company
Peekskill,	Peekskill Lighting and Railroad Company
Port Jervis,	Port Jervis Electric Light, Power, Gas and Railroad Company
Potsdam,	The Potsdam Electric Light and Power Company
Poughkeepsie,	Poughkeepsie Light, Heat and Power Company
Richfield Springs,	Richfield Springs Electric Light and Power Company
Rochester,	Rochester Railway and Light Company
Rome,	The Rome Gas, Electric Light and Power Company
Roslyn,	Nassau Light and Power Company
Saranac Lake,	Saranac Lake Light, Heat and Power Company
Schenectady,	Schenectady Illuminating Company
Syracuse,	Syracuse Lighting Company
Tuxedo Park,	Tuxedo Electric Lighting Company
Utica,	Utica Gas and Electric Company
Watertown,	Watertown Electric Light Company
Yonkers,	Yonkers Electric Light and Power Company

NORTH CAROLINA

Asheville,	Asheville Electric Company
Charlotte,	Catawba Power Company
Durham,	Durham Traction Company
Henderson,	Henderson Lighting and Power Company
Raleigh,	The Raleigh Electric Company
Winston-Salem,	The Fries Manufacturing and Power Company

NORTH DAKOTA

GRAND FORKS,	Grand Forks Gas and Electric Company
MANDAN,	Mandan Electric Company
MINOT,	Minot Light and Telephone Company

OHIO

AKRON,	The Northern Ohio Traction and Light Company
ALLIANCE,	The Alliance Gas and Electric Company
BARNESVILLE,	Barnesville Gas and Electric Light Company
CANTON,	Canton Light, Heat and Power Company
CHILLICOTHE,	The Chillicothe Electric Railroad, Light and Power Company
CINCINNATI,	Union Gas and Electric Company
CLEVELAND,	The Cleveland Electric Illuminating Company
COLUMBUS,	Columbus Railway and Light Company
DAYTON,	The Dayton Lighting Company
DEFIANCE,	The People's Gas and Electric Company
EAST LIVERPOOL,	The East Liverpool Traction and Light Company
ELYRIA,	Citizens' Gas and Electric Company
LANCASTER,	Lancaster Electric Light Company
LEIPSIC,	Cottingham and Franklin
LIMA,	The Lima and Toledo Traction Company
MASSILLON,	Massillon Light, Heat and Power Company
NEWARK,	The Licking Light and Power Company
PIQUA,	Miami Light, Heat and Power Company
PORTSMOUTH,	Portsmouth Street Railway and Light Company
SALEM,	The Salem Electric Light and Power Company
SPRINGFIELD,	The People's Light, Heat and Power Company
STEUBENVILLE,	Steubenville Traction and Light Company
TOLEDO,	The Toledo Gas, Electric and Heating Company
	The Toledo Railways and Light Company
WARREN,	The Warren Water and Light Company
YOUNGSTOWN,	The Youngstown Consolidated Gas and Electric Company
ZANESVILLE,	The Zanesville Railway, Light and Power Company

OKLAHOMA

GUTHRIE,	The Guthrie Light and Power Company
SHAWNEE,	Shawnee Light and Power Company

OREGON

ASHLAND,	Ashland Electric Power and Light Company
BAKER CITY,	Baker Light and Power Company
PORTLAND,	Portland General Electric Company
TOLO,	Condor Water and Power Company

PENNSYLVANIA

ALLENTOWN,	The Allentown Electric Light Company
ALTOONA,	The Edison Electric Illuminating Company
ARDMORE,	Merion and Radnor Gas and Electric Company
BERWICK,	Berwick Electric Light Company
BRADFORD,	Bradford Electric Light and Power Company
CARBONDALE,	Lackawanna Valley Electric Light and Power Supply Company
CARLISLE,	The Carlisle Gas and Water Company
CHAMBERSBURG,	United Electric Company
CHESTER,	Beacon Light Company
CLEARFIELD,	Central Pennsylvania Light and Power Company
CONNELLSVILLE,	West Penn Electric Company
CONSHOHOCKEN,	Conshohocken Electric Light and Power Company
DANVILLE,	Standard Electric Light Company
DOYLESTOWN,	Doylestown Electric Company
EASTON,	Easton Gas and Electric Company
FRANKLIN,	Franklin Electric Company
HANOVER,	Hanover Light, Heat and Power Company
JERSEY SHORE,	Jersey Shore Electric Company
LANCASTER,	Lancaster Electric Light, Heat and Power Company
LEWISTOWN,	The Mifflin County Gas and Electric Company
MCCALL FERRY,	McCall Ferry Power Company
MORTON,	Faraday Heat, Power and Light Company
NEW CASTLE,	New Castle Electric Company
NORRISTOWN,	Norristown Electric Light and Power Company
OIL CITY,	Citizens' Light and Power Company
PHILADELPHIA,	The Electric Company of America
	The Philadelphia Electric Company
	The United Gas Improvement Company
PHŒNIXVILLE,	Schuylkill Valley Illuminating Company
PITTSBURGH,	The Allegheny County Light Company
PITTSTON,	Citizens' Electric Illuminating Company
READING,	Metropolitan Electric Company
RENOVO,	Renovo Edison Light, Heat and Power Company
SCRANTON,	Scranton Illuminating, Heat and Power Company
TOWANDA,	Towanda Electric Illuminating Company
TYRONE,	Home Electric Light and Steam Heating Company
WARREN,	Warren Electrical Light Company
WASHINGTON,	The Washington Electric Light and Power Company
WAYNESBORO,	Waynesboro Electric Light and Power Company
WAYNESBURG,	Waynesburg Electric Light and Power Company
WEST CHESTER,	The Edison Electric Illuminating Company
WILKES-BARRE,	Wilkes-Barre Gas and Electric Company
WILLIAMSPORT,	Lycoming Electric Company
WYNCOTE,	The Jenkintown Light Company
YORK,	Edison Electric Light Company

PHILIPPINE ISLANDS

MANILA,	Manila Electric Railroad and Light Company

PORTO RICO

SAN JUAN,	San Juan Light and Transit Company

RHODE ISLAND

NEWPORT,	Newport and Fall River Street Railway Company
PAWTUCKET,	Pawtucket Electric Company
PROVIDENCE,	Narragansett Electric Lighting Company
WOONSOCKET,	Woonsocket Electric Machine and Power Company

SOUTH CAROLINA

CHARLESTON,	Charleston Consolidated Railway, Gas and Electric Company
COLUMBIA,	The Columbia Electric Street Railway, Light and Power Company
GEORGETOWN,	Georgetown Electric Company

SOUTH DAKOTA

LEAD,	Consolidated Power and Light Company
RAPID CITY,	Rapid City Electric and Gas Light Company

TENNESSEE

BRISTOL,	Bristol Gas and Electric Company
CHATTANOOGA,	Chattanooga Electric Company
COLUMBIA,	Columbia Water and Light Company
KNOXVILLE,	Knoxville Railway and Light Company
MEMPHIS,	Memphis Consolidated Gas and Electric Company
NASHVILLE,	Nashville Railway and Light Company

TEXAS

BEAUMONT,	Beaumont Ice, Light and Refrigerating Company
CLEBURNE,	Cleburne Gas and Electric Company
CORSICANA,	Corsicana Gas and Electric Company
DALLAS,	Dallas Electric Light and Power Company
EL PASO,	El Paso Electric Railway Company
GAINESVILLE,	Gainesville Electric Railway and Light Company
GALVESTON,	Brush Electric Light and Power Company
HOUSTON,	Houston Lighting and Power Company
MARSHALL,	Arkansas and Texas Consolidated Ice and Coal Company
ORANGE,	Orange Ice, Light and Water Company
PARIS,	Paris Light and Power Company
SAN ANTONIO,	San Antonio Gas and Electric Company

TEXAS—*Continued*

SHERMAN,	Sherman Gas and Electric Company
TYLER,	Tyler Electric Light and Power Company
WEATHERFORD,	City of Weatherford Water, Light and Ice Company

UTAH

EUREKA,	Eureka Electric Company
SALT LAKE CITY,	Utah Light and Railway Company

VERMONT

BELLOWS FALLS,	The Fall Mountain Electric Light and Power Company
BENNINGTON,	Bennington Electric Company
BRANDON,	Neshobe Electric Company
BRATTLEBORO,	Twin State Gas and Electric Company
BURLINGTON,	Burlington Light and Power Company
FAIR HAVEN,	Fair Haven Electric Company
MIDDLEBURY,	Middlebury Electric Company
MONTPELIER,	Consolidated Lighting Company
RUTLAND,	Rutland City Electric Company
ST. JOHNSBURY,	St. Johnsbury Electric Company
VERGENNES,	Vergennes Electric Company

VIRGINIA

LYNCHBURG,	Lynchburg Traction and Light Company
NORFOLK,	The Norfolk Railway and Light Company
RICHMOND,	Virginia Passenger and Power Company
ROANOKE,	Roanoke Railway and Electric Company

WASHINGTON

ABERDEEN,	Gray's Harbor Electric Company
EVERETT,	Everett Railway, Light and Water Company
NORTH YAKIMA,	Northwest Light and Water Company
OLYMPIA,	Olympia Light and Power Company
SEATTLE,	Seattle-Tacoma Power Company
	The Seattle Electric Company
SPOKANE,	The Washington Water Power Company
WALLA WALLA,	Northwestern Gas and Light Company
WENATCHEE,	Wenatchee Electric Company

WEST VIRGINIA

BLUEFIELD,	East River Electric Company
CHARLESTON,	Kanawha Water and Light Company
FAIRMONT,	Fairmont and Clarksburg Traction Company
PARKERSBURG,	Parkersburg, Marietta and Inter-Urban Railway Company

WEST VIRGINIA—*Continued*

Point Pleasant,	Point Pleasant Water and Light Company
Sistersville,	Sistersville Electric Light and Power Company
Welch,	Welch Water, Light and Power Company
Wheeling,	The Wheeling Electrical Company

WISCONSIN

Antigo,	Antigo Electric Light Plant
Ashland,	Ashland Light, Power and Street Railway Company
Delavan,	Delavan Light and Fuel Company
Eau Claire,	Chippewa Valley Electric Railroad Company
Fond-du-Lac,	Eastern Wisconsin Railway and Light Company
Janesville,	Janesville Electric Company
Kenosha,	Kenosha Gas and Electric Company
La Crosse,	La Crosse Gas and Electric Company
Madison,	Madison Gas and Electric Company
Menomonie,	Menomonie Electric Light and Power Company
Merrill,	Merrill Railway and Lighting Company
Oconto,	Oconto Electric Company
Oshkosh,	Oshkosh Gas Light Company
Port Washington,	Wisconsin Chair Company
Rhinelander,	Rhinelander Lighting Company
Sheboygan,	Sheboygan Light, Power and Railway Company
Sparta,	O. I. Newton's Sons Company
Watertown,	Watertown Gas and Electric Company
Waukesha,	Waukesha Gas and Electric Company
Waupaca,	Waupaca Electric Light and Railway Company
Wausau,	Wausau Electric Company

WYOMING

Cheyenne,	Cheyenne Light, Fuel and Power Company
Evanston,	Evanston Electric Light Company
Green River,	Green River Electric Light and Power Company
Laramie,	Laramie Light and Power Company
Rawlins,	The Rawlins Electric Light and Fuel Company
Sheridan,	The Sheridan Electric Light and Power Company

CANADA

BRITISH COLUMBIA

Vancouver,	British Columbia Electric Railway Company, Limited

ONTARIO

London,	London Electric Company, Limited
Niagara Falls,	The Ontario Power Company of Niagara Falls
Ottawa,	The Ottawa Electric Company
Sault Ste. Marie,	Tagona Water and Light Company
Toronto,	Toronto and Niagara Power Company

QUEBEC

Montreal,	The Montreal Heat, Light and Power Company
Quebec,	Quebec-Jacques Cartier Electric Company
	Quebec Railway, Light and Power Company
Sherbrooke,	The Sherbrooke Power, Light and Heat Company

YUKON TERRITORY

White Horse,	The Yukon Electrical Company, Limited

MEXICO

Mexico,	Mexican Light and Power Company

SOUTH AMERICA

BRAZIL

Sao Paulo,	Sao Paulo Tramway Light and Power Company

TRINIDAD

Port of Spain,	Trinidad Electric Company

MEMBERS—CLASS B

Abell, H. C., Muskegon Traction and Lighting Company, New York, N. Y.
Adams, W. L., The Ontario Power Company of Niagara Falls, Niagara Falls, N. Y.
Akins, Sage, Lewis-Clarkston Company, Asotin, Wash.
Allegaert, Edgar J., Public Service Corporation of New Jersey, Newark, N. J.
Allen, A. S., Tonawanda Power Company, North Tonawanda, N. Y.
Allen, E. G., The Seattle Electric Company, Seattle, Wash.
Andrew, J. D., New York Edison Company, New York, N. Y.
Arms, R. M., Seattle Electric Company, Seattle, Wash.
Atkins, Wm. H., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Bache, R. P., Public Service Corporation of New Jersey, Plainfield, N. J.
Baehr, Wm. A., Laclede Gas Light Company, St. Louis, Mo.
Baker, Frank J., North Shore Electric Company, Evanston, Ill.
Ballard, R. H., The Edison Electric Company, Los Angeles, Calif.
Ballinger, P. F., Consolidated Gas Company of New York, Long Branch, N. J.
Balsley, A., Sao Paulo Tramway Light and Power Company, New York, N. Y.
Barrows, Edwin A., Narragansett Electric Lighting Company, Providence, R. I.
Barstow, W. S., Portland General Electric Company, New York, N. Y.
Bechtel, E. J., Toledo Railways and Light Company, Toledo, Ohio.
Belcher, Walter A., Public Service Corporation of New Jersey, Perth Amboy, N. J.
Bement, A., Chicago Edison Company, Chicago, Ill.
Bishop, Jas. W., The Peninsular Electric Company, Detroit, Mich.
Black, A. L., New Orleans and Carrollton Railroad, Light and Power Company, New Orleans, La.
Blood, W. H., Jr., Seattle Electric Company, Boston, Mass.
Boyd, Walter R., New York Edison Company, New York, N. Y.
Brock, Wm. M., Public Service Corporation of New Jersey, Paterson, N. J.
Brockway, W. B., Nashville Railway and Light Company, Yonkers, N. Y.
Broili, F. O., Truckee River General Electric Company, Reno, Nev.
Brown, Crawford R., The Edison Electric Illuminating Company of Boston, Mass.
Bullard, A. W., The Topeka Edison Company, Chicago, Ill.
Bullock, F. W., Jamestown Lighting and Power Company, Jamestown, N. Y.
Bump, Milan R., Denver Gas and Electric Company, Denver, Colo.

Burnett, Douglass, Consolidated Gas, Electric Light and Power Company, Baltimore, Md.

Bushnell, O. J., Chicago Edison Company, Chicago, Ill.

Caldwell, Eliot L., The Edison Electric Illuminating Company of Boston, Boston, Mass.

Campbell, Alex. J., New London Gas and Electric Company, New London, Conn.

Cato, George W., The Peninsular Electric Light Company, Detroit, Mich.

Causbrook, Wm. A., Public Service Corporation of New Jersey, Plainfield, N. J.

Chambers, H. P., The Washington Electric Light and Power Company, Washington, Pa.

Chandler, H. P., Public Service Corporation of New Jersey, Newark, N. J.

Claflin, George E., Omaha Electric Light and Power Company, Boston, Mass.

Clark, Robert J., Colorado Springs Electric Company, Colorado Springs, Colo.

Cobb, B. C., Bartlett Illuminating Company, Saginaw, Mich.

Colby, Leroy S., Lawrence Gas Company, Lawrence, Mass.

Collins, W. Ben., Lake Charles Ice, Light and Water Works Company, Lake Charles, La.

Cowles, J. E., Hot Springs Water Company, Hot Springs, Ark.

Cowles, J. W., The Edison Electric Illuminating Company of Boston, Boston, Mass.

Crary, J. D., Gray's Harbor Electric Company, Aberdeen, Wash.

Crawford, L. R., Sioux City Service Company, Sioux City, Ia.

Curtis, S. P., Burlington Light and Power Company, Burlington, Vt.

Cushman, G. H., San Antonio Gas and Eectric Company, San Antonio, Tex.

Dabney, Frank, The Seattle Electric Company, Seattle, Wash.

Dallas, Robt. E., United Gas Improvement Company, Philadelphia, Pa.

Dame, F. L., Des Moines Edison Light Company, New York, N. Y.

Davenport, E. R., Narragansett Electric Lighting Company, Providence, R. I.

Davis, Ernest H., Lycoming Electric Company, Williamsport, Pa.

Day, Robert W., United Electric Light Company, Springfield, Mass.

Deal, E. C., Public Service Corporation of New Jersey, Hackensack, N. J.

Dillon, E. P., Colorado Springs Electric Company, Colorado Springs, Colo.

Doherty, Henry L., The Denver Gas and Electric Company, New York City.

Donkin, Wm. A., The Allegheny County Light Company, Pittsburgh, Pa.

Dupont, Wm. D., Public Service Corporation of New Jersey, Newark, N. J.

Duryee, L. S., Everett Railway, Light and Power Company, Everett, Wash.

Edgar, Charles L., The Edison Electric Illuminating Company of Boston, Boston, Mass.

Edwards, H. M., New York Edison Company, New York, N. Y.

Eglin, Wm. C. L., The Philadelphia Electric Company, Philadelphia, Pa.
Elden, Leonard L., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Elliott, J. G., Public Service Corporation of New Jersey, Newark, N. J.
Emerson, Edwin J., Dallas Electric Light and Power Company, Dallas, Tex.
Emery, James A., Birmingham Railway, Light and Power Company, Birmingham, Ala.
Farrand, Dudley, Public Service Corporation of New Jersey, Newark, N. J.
Fling, Harry C., New York Edison Company, New York, N. Y.
Fowler, E. J., Chicago Edison Company, Chicago, Ill.
Francis, W. H., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Fraser, William, New London Gas and Electric Company, New London, Conn.
French, E. R., Public Service Corporation of New Jersey, Newark, N. J.
Frueauff, Frank W., Denver Gas and Electric Company, Denver, Colo.
Fuller, George A., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Gaffney, John J., Public Service Corporation of New Jersey, Newark, N. J.
Gardiner, W. H., Jr., Boston Consolidated Gas Company, Boston, Mass.
Gilchrist, John F., The Chicago Edison Company, Chicago, Ill.
Goettling, Gerhard M. W., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Goldman, Albert, New York Edison Company, New York, N. Y.
Goodale, Roy Lewis, Colorado Springs Electric Company, Colorado Springs, Colo.
Grambs, W. J., Seattle Electric Company, Seattle, Wash.
Greacen, W., Jr., Public Service Corporation of New Jersey, Hoboken, N. J.
Hammack, R. A., Montgomery Light and Water Power Company, Montgomery, Ala.
Hancock, W. P., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Hatch, Charles J., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Hayward, R. F., Mexico Light and Power Company, Mexico, Mex.
Heaton, Laurent, Poughkeepsie Light, Heat and Power Company, Poughkeepsie, N. Y.
Herrick, Charles H., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Hertz, Adolph, New York Edison Company, New York, N. Y.
Hess, Paul A., Lycoming Electric Company, Williamsport, Pa.
Higgins, Corwin, Duluth Edison Electric Company, Duluth, Minn.
Hires, B. F., Bridgeton Electric Company, Bridgeton, N. J.
Hodskinson, Charles H., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Hoeveler, J. A. E., Allegheny County Light Company, Pittsburgh, Pa.

Holberton, George C., Oakland Gas Light and Heat Company, Oakland, Calif.

Hosmer, Sidney, The Edison Electric Illuminating Company of Boston, Boston, Mass.

Houston, A. W., Jr., Consolidated Gas Company of New Jersey, Long Branch, N. J.

Howell, David J., Welch Water, Light and Power Company, Washington, D. C.

Humphreys, C. J. R., Lawrence Gas Company, Lawrence, Mass.

Huntress, F. A., Sao Paulo Tramway Light and Power Company, New York, N. Y.

Ingalls, Percy, Public Service Corporation of New Jersey, Newark, N. J.

Insull, Fred. W., North Shore Electric Company, Evanston, Ill.

Insull, Samuel, Chicago Edison Company, Chicago, Ill.

Jackson, W. B., Janesville Electric Company, Madison, Wis.

Johns, S. C. D., The Cleveland Electric Illuminating Company, Cleveland, O.

Johnson, Walter H., Philadelphia Electric Company, Philadelphia, Pa.

Jones, Geo. Harvey, Chicago Edison Company, Chicago, Ill.

Keeler, J. P., Asheville Electric Company, Asheville, N. C.

Kennedy, D., Colorado Springs Electric Company, Colorado Springs, Colo.

Kennedy, J., Public Service Corporation of New Jersey, Weehawken Heights, N. J.

Kent, E. G., Public Service Corporation of New Jersey, Jersey City, N. J.

Kermode, John, The Cleveland Electric Illuminating Company, Cleveland, O.

Kibbe, A. S., Home Electric Light and Steam Heating Co., Philadelphia, Pa.

King, E. D., The Ontario Power Company of Niagara Falls, Ontario, Canada.

King, H. D., Public Service Corporation of New Jersey, Hoboken, N. J.

Kohler, D. S., The Allegheny County Light Company, Pittsburgh, Pa.

Lathrop, Alanson P., Saint Paul Gas Light Company, New York, N. Y.

Lawrence, W. H., New York Edison Company, New York, N. Y.

Leigh, Albert, Fall River Electric Light Company, Fall River, Mass.

Lewis, W. M., Rockville Gas and Electric Company, Rockville, Conn.

Lieb, J. W., Jr., New York Edison Company, New York, N. Y.

Lincoln, Wm. A., United Electric Light Company, Springfield, Mass.

Linn, Arthur L., Jr., Rochester Railway and Light Company, New York, N. Y.

Littell, H. M., San Antonio Gas and Electric Company, San Antonio, Tex.

Little, Francis W., Peoria Gas and Electric Company, Peoria, Ill.

Littlefield, C. Alfred, New York Edison Company, New York, N. Y.

Lloyd, E. W., Chicago Edison Company, Chicago, Ill.

Lukes, Geo. H., North Shore Electric Company, Evanston, Ill.

Lüpke, Paul, Public Service Corporation of New Jersey, Trenton, N. J.

Lynch, A. H., Public Service Corporation, of New Jersey, Morristown, N. J.

MacConnell, Theo., Colorado Light and Power Company, Cripple Creek, Colo.
Manwaring, A. H., The Philadelphia Electric Company, Philadelphia, Pa.
Marks, Thos., Duluth Edison Electric Company, Duluth, Minn.
McAlpin, M. F., New York Edison Company, New York, N. Y.
McCall, Jos. B., The Philadelphia Electric Company, Philadelphia, Pa.
McCarthy, J. M., Quebec-Jacques Cartier Electric Company, Quebec, Canada.
McCoy, W. E., The United Electric Light and Power Company, New York, N. Y.
McDonald, W. B., Evansville Gas and Electric Light Company, Evansville, Ind.
McFeeley, Jno., Public Service Corporation of New Jersey, Bristol, Pa.
Miller, John B., The Edison Electric Company, Los Angeles, Calif.
Moon, Wm., Fulton Light, Heat and Power Company, Fulton, N. Y.
Moore, J. L., Public Service Corporation of New Jersey, Camden, N. J.
Morrison, W. T., New York Edison Company, New York, N. Y.
Moultrop, Irving E., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Muller, H. N., The Allegheny County Light Company, Pittsburgh, Pa.
Murphy, John, Ottawa Electric Company, Ottawa, Ontario.
Murray, J. W., The Allegheny County Light Company, Pittsburgh, Pa.
Murray, Thos. E., New York Edison Company, New York, N. Y.
Neumuller, Walter, New York Edison Company, New York, N. Y.
Niesz, Homer E., Chicago Edison Company, Chicago, Ill.
Norman, Edward A., New York Edison Company, New York, N. Y.
Nunn, Josiah J., The Telluride Power Company, Provo, Utah.
Nunn, P. N. The Telluride Power Company, Niagara Falls, N. Y.
O'Beirne, Edward J., Gainesville Electric Railway and Light Company, Atlanta, Ga.
Orrok, Geo. A., New York Edison Company, New York, N. Y.
Parker, Charles H., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Parmelee, James, The Cleveland Electric Illuminating Company, Cleveland, O.
Partridge, Warren, Public Service Corporation of New Jersey, Orange, N. J.
Patten, G. H., Chattanooga Electric Company, Chattanooga, Tenn.
Patterson, Arthur C., Everett Railway, Light and Power Company, Everett, Wash.
Peck, Edward F., Schenectady Illuminating Company, Schenectady, N. Y.
Perkins, Jas. B., New London Gas and Electric Company, New London, Conn.
Phinney, E. A., Ouray Electric Power and Light Company, Ouray, Colo.
Plummer, H. W., Asheville Electric Company, Asheville, N. C.
Pomeroy, Arthur, The Cleveland Electric Illuminating Company, Cleveland, O.

Pope, A. A., New York Edison Company, New York, N. Y.
Power, W. R., Home Electric Light and Steam Heating Company, Tyrone, Pa.
Purcell, Thos. E., Billings Water Power Company, Billings, Mont.
Reesman, John S., North Shore Electric Company, Highland Park, Ill.
Richards, E. J., Newburgh Light, Heat and Power Company, Newburgh, N. Y.
Richardson, H. C., Public Service Corporation of New Jersey, Metuchen, N. J.
Rix, Anson F., East River Electric Company, Bluefield, W. Va.
Roberts, Ernest C., Public Service Corporation of New Jersey, Hackensack, N. J.
Robison, Chas. D., Rockland Light and Power Company, Nyack, N. Y.
Rogers, W. H., Public Service Corporation of New Jersey, Paterson, N. J.
Ross, K. J., Citizens' Electric Illuminating Company, Pittston, Pa.
Russell, Chas. J., The Philadelphia Electric Company, Philadelphia, Pa.
Ryerson, W. N., The Ontario Power Company of Niagara Falls, Ontario, Canada.
Scherck, Leon H., Birmingham Railway, Light and Power Company, New York City.
Schmidt, F. W., Public Service Corporation of New Jersey, Jersey City, N. J.
Schwabe, Walter P., Public Service Corporation of New Jersey, Rutherford, N. J.
Shaw, J. A., Montreal Light, Heat and Power Company, Montreal, Canada.
Shepard, Chas. S., New York Edison Company, New York, N. Y.
Sheridan, Sarah M., Peninsular Electric Light Company, Detroit, Mich.
Sherwin, John J., The United Hydro-Electric Company, Idaho Springs, Colo.
Smith, F. Ellwood, The Edison Electric Illuminating Company of Boston, W. Somerville, Mass.
Sohier, Walter, The Lowell Electric Light Corporation, Lowell, Mass.
Stelling, C. A., Public Service Corporation of New Jersey, Passaic, N. J.
Stephenson, Henry, New York Edison Company, New York, N. Y.
Stevens, E. H., Public Service Corporation of New Jersey, Newark, N. J.
Stroud, Morris W., Kingston Gas and Electric Company, Philadelphia, Pa.
Sturtevant, W. I., The Paducah Light and Power Company, Paducah, Ky.
Sullivan, R. B., Denver Gas and Electric Company, Denver, Colo.
Thompson, Wright B., Peninsular Electric Light Company, Detroit, Mich.
Titzell, W. W., Public Service Corporation of New Jersey, Jersey City, N. J.
Tripp, Geo. B., Colorado Springs Electric Company, Colorado Springs, Colo.
Tuell, Samuel B., Terre Haute Traction and Light Company, Terre Haute, Ind.
Turner, M. E., The Cleveland Electric Illuminating Company, Cleveland, O.
Tuttle, W. B., Consolidated Gas Company, Long Branch, N. J.
Uhlenhart, F. Jr., Allegheny County Light Company, Pittsburgh, Pa.

Urban, O. C. G., Key West Electric Company, Key West, Fla.
Voorhees, Geo. A., Poughkeepsie Light, Heat and Power Company, Poughkeepsie, N. Y.
Vredenburgh, LaRue, The Edison Electric Illuminating Company of Boston, Boston, Mass.
Wallace, L. M., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Wallace, R. S., Peoria Gas and Electric Company, Peoria, Ill.
Wallau, H. L., The Cleveland Electric Illuminating Company, Cleveland, O.
Walsmley, W. N., Sao Paulo Tramway, Light and Power Company, Sao Paulo, Brazil, S. Am.
Wells, H. H., Public Service Corporation of New Jersey, Orange, N. J.
Wendle, George E., Lycoming Electric Company, Williamsport, Pa.
White, W. F., Peninsular Electric Light Company, New York, N. Y.
Whitely, Benjamin, The United Electric Light and Power Company, New York, N. Y.
Whittlesey, Jas. T., Public Service Corporation of New Jersey, Montclair, N. J.
Whittlesey, W. A., Jr., Pittsfield Electric Company, Pittsfield, Mass.
Whitton, W. H., New York Edison Company, New York, N. Y.
Williams, Arthur, New York Edison Company, New York, N. Y.
Willis, H. L., Georgia Railway and Electric Company, Atlanta, Ga.
Wilson, H. H., The Ontario Power Company of Niagara Falls, Ontario, Canada.
Wilson, John A., Public Service Corporation of New Jersey, Trenton, N. J.
Witherby, Edwin E., Lockport Gas and Electric Company, New York, N. Y.
Wolff, S. E., Bartlett Illuminating Company, Saginaw, Mich.
Woodward, Wm. C., Narragansett Electric Lighting Company, Providence, R. I.
Yawger, Thomas H., Rochester Railway and Light Company, Rochester, N. Y.
Young, J. W., McCall Ferry Power Company, New York, N. Y.
Young, O. H., Wabash Water and Light Company, Wabash, Ind.
Young, Percy S., Public Service Corporation of New Jersey, Newark, N. J.
Young, R. R., Public Service Corporation of New Jersey, Passaic, N. J.

MEMBERS—CLASS C

Adams, Comfort A., Harvard University, Cambridge, Mass.
Brown, Charles F., Vanderbilt College, Nashville, Tenn.
Caldwell, Francis C., Ohio State University, Columbus, Ohio.
Clifford, H. E., Massachusetts Institute of Technology, Boston, Mass.
Comstock, Charles W., 213 Boston Building, Denver, Colo.
Cooper, Frank L., Johns Hopkins University, Baltimore, Md.
Crain, L. D., State Agricultural College, Fort Collins, Colo.
Dates, Henry B., School of Applied Science, Cleveland, Ohio.
Freedman, W. H., University of Vermont, Burlington, Vt.
Green, Jerome J., University of Notre Dame, Notre Dame, Ind.
Hazard, William J., Colorado School of Mines, Golden, Colo.
Hirokawa, T., Doshisha College, Kyoto, Japan.
Jackson, Dugald C., University of Wisconsin, Madison, Wis.
Kay, Edgar B., University of Alabama, Tuscaloosa, Ala.
Kennelly, A. E., Harvard University, Cambridge, Mass.
Kent, James M., Manual Training High School, Kansas City, Mo.
Kent, William, College of Applied Science, Syracuse, N. Y.
Lawrence, Ralph R., Massachusetts Institute of Technology, Boston, Mass
Lee, Claudius, Virginia Polytechnic Institute, Blacksburg, Va.
Macomber, George Stanley, Sibley College, Cornell University, Ithaca, N. Y.
Magnusson, Carl Edward, University of Washington, Seattle, Wash.
Noble, G. C., University of California, Berkeley, Calif.
Norris, Henry H., Cornell University, Ithaca, N. Y.
Patten, H. E., University of Wisconsin, Madison, Wis.
Patterson, George W., University of Michigan, Ann Arbor, Mich.
Perrine, Frederic A. C., Polytechnic Institute, Brooklyn, N. Y.
Radtke, A. A., Armour Institute, Chicago, Ill.
Rowland, Arthur J., Drexel Institute, Philadelphia, Pa.
Ryan, Harris J., Stanford University, Calif.
Sawyer, A. R., Agricultural College, Lansing, Mich.
Shaad, Geo. C., University of Wisconsin, Madison, Wis.
Shaw, H. B., University of Missouri, Columbia, Mo.
Sheldon, Dr. Samuel, Polytechnic Institute, Brooklyn, N. Y.
Shepardson, George D., University of Minnesota, Minneapolis, Minn.
Smith, Harold Babbitt, Worcester Polytechnic Institute, Worcester, Mass.
Smith, Harrison W., Massachusetts Institute of Technology, Boston, Mass.
Swenson, B. V., University of Wisconsin, Madison, Wis.
Thaler, Joseph A., Montana Agricultural College, Bozeman, Mont.
Wilson, Alexander Massey, Kentucky State College, Lexington, Ky.
Wolcott, E. R., Colorado School of Mines, Golden, Colo.

ASSOCIATE MEMBER COMPANIES—CLASS D

AMPERE, N. J.,	Crocker-Wheeler Company
AUBURN, N. Y.,	McIntosh, Seymour and Company
BALTIMORE, MD.	Electrical Material Company
BOSTON, MASS.,	Albert and J. M. Anderson Manufacturing Company
	American Telephone and Telegraph Company
	Condit Electrical Manufacturing Company
	Electrical Auditing Company
	Electrical Goods Manufacturing Company
	Frank Ridlon Company
	Herbert S. Potter
	J. S. Codman and Company
	Massachusetts Chemical Company
	McKenney and Waterbury Company
	New England Telephone and Telegraph Company
	Pettingell-Andrews Company
	Stuart-Howland Company
	The Lundin Electric and Machine Company
	The Simplex Electrical Company
BRIDGEPORT, CONN.,	Bryant Electric Company
BROOKLYN, N. Y.,	Metropolitan Engineering Company
BUFFALO, N. Y.,	National Battery Company
CHELSEA, MASS.,	American Circular Loom Company
CHICAGO, ILL.	Addressograph Company
	American Electrical Supply Company
	Chicago Fuse Wire and Manufacturing Company
	Dearborn Drug and Chemical Works
	Electrical Appliance Company
	Federal Electric Company
	Gregory Electric Company
	The Arnold Company
	Western Electric Company
	Western Electrician
CINCINNATI, OHIO,	Triumph Electric Company
CLEVELAND, OHIO,	Adams-Bagnall Electric Company
	Buckeye Electric Company
	Co-operative Electrical Development Association
	National Carbon Company
COVINGTON, KY.,	Hemingray Glass Company
DAYTON, OHIO,	National Cash Register Company
DETROIT, MICH.,	American Electrical Heater Company
	Curtis Advertising Company
	The Phelps Company

Fort Wayne, Ind.,	Fort Wayne Electric Works
Fostoria, Ohio,	Crouse-Tremaine Carbon Company
Hartford, Conn.,	Automatic Refrigerating Company
Indianapolis, Ind.,	Pope Motor Car Company
Jamaica Pl'n, Mass.,	John L. Gleason
Jonesboro, Ind.,	Indiana Rubber and Insulated Wire Company
Keokuk, Ia.,	Garton-Daniels Company
Lafayette, Ind.,	Duncan Electric Manufacturing Company
Lockport, N. Y.,	American District Steam Company
Matteawan, N. Y.,	The Green Fuel Economizer Company
Milwaukee, Wis.,	Allis-Chalmers Company
	National Brake and Electric Company
Newark, N. J.,	Baker and Company, Incorporated
	The C. W. Lee Company
	Weston Electrical Instrument Company
New Britain, Conn.,	T. H. Brady
Newburyport, Mass.,	Chase-Shawmut Company
New York City,	Alberger Condenser Company
	American Diesel Engine Company
	American Vibrator Company
	American Vitrified Conduit Company
	Association of Licensed Manufacturers of Incandescent Lamps
	Atlantic Insulated Wire and Cable Company
	Beck Flaming Lamp Company
	Bryan-Marsh Company
	Converse D. Marsh
	De La Vergne Machine Company
	Electrical Review Publishing Company
	Electrical Testing Laboratories
	Ford, Bacon and Davis
	Franklin H. Kalbfleisch Company
	General Electric Company
	General Storage Battery Company
	Gould Storage Battery Company
	H. B. Camp Company
	Holophane Glass Company
	Hugo Reisinger
	H. W. Johns-Manville Company
	Illuminating Engineering Publishing Company
	India Rubber and Gutta Percha Insulating Company
	Jeremiah J. Kennedy
	J. G. White and Company
	J. Henry Hallberg
	John A. Roebling's Sons Company
	McGraw Publishing Company

NEW YORK CITY,	Michaelis and Ellsworth
	National Conduit and Cable Company
	National Metal Moulding Company
	New York Insulated Wire Company
	Otis Elevator Company
	Power and Mining Machinery Company
	Rossiter, MacGovern and Company
	Sanderson and Porter
	Sawyer-Man Electric Company
	Southern Exchange Company
	Sprague Electric Company
	Standard Vitrified Conduit Company
	The *Central Station*
	The Dale Company
	The *Electrical Age*
	The Excello Arc Lamp Company
	The Okonite Company, Limited
	The Phoenix Glass Company
	The Standard Paint Company
	Tipless Lamp Company
NIAGARA FALLS, N.Y.,	Niagara Tachometer Instrument Company
ONEIDA, N. Y.,	Oneida Community, Limited
ORANGEBURG, N. Y.,	The Fibre Conduit Company
PHILADELPHIA, PA.,	Alfred F. Moore
	American Instrument Company
	Electric Storage Battery Company
	James H. Dawes
	The Philadelphia Electrical and Manufacturing Company
	The Shelby Electric Company
PITTSBURGH, PA.,	Doubleday-Hill Electric Company
	Nernst Lamp Company
	Pittsburgh Transformer Company
	Standard Underground Cable Company
	The Pittsburgh Reduction Company
	The Westinghouse Machine Company
	Westinghouse Electric and Manufacturing Company
PITTSFIELD, MASS.,	Stanley-G. I. Electric Manufacturing Company
PROVIDENCE, R. I.,	American Electrical Works
	D. and W. Fuse Company
	New England Butt Company
ST. LOUIS, MO.,	Columbia Incandescent Lamp Company
	The Emerson Electric Manufacturing Company
	The Wesco Supply Company
	Wagner Electric Manufacturing Company
SPRINGFIELD, MASS.,	Munder Electrical Works
	Sangamo Electric Company
SYRACUSE, N. Y.,	Pass and Seymour

Toronto, Ontario, Canada,	Roderick J. Parke
Trenton, N. J.,	De Laval Steam Turbine Company
Utica, N. Y.,	Frank G. Scofield
Warren, Ohio,	New York and Ohio Company
W. New Brighton, N. Y.,	C. W. Hunt Company
Worcester, Mass.,	American Steel and Wire Company

ASSOCIATE MEMBERS—CLASS E

Abell, A. H., Stanley-G. I. Manufacturing Company, Pittsfield, Mass.
Addison, Dr. Thomas, General Electric Company, San Francisco, Calif.
Babson, A. D., General Electric Company, New York City.
Barbour, F. F., General Electric Company, San Francisco, Calif.
Barr, J. M., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Bates, F. C., General Electric Company, New York City.
Behrend, B. A., Allis-Chalmers Company, Cincinnati, Ohio.
Beran, T., General Electric Company, New York City.
Bogen, L. E., Allis-Chalmers Company, Cincinnati, Ohio.
Boyer, F. N., General Electric Company, Chicago, Ill.
Brady, Paul T., Westinghouse Electric and Manufacturing Company, Syracuse, N. Y.
Buckley, W. J., Allis-Chalmers Company, St. Louis, Mo.
Buddy, H. C., General Electric Company, Philadelphia, Pa.
Bullen, D. R., General Electric Company. Schenectady, N. Y.
Burleigh, Chas. E., General Electric Company, Boston, Mass.
Clark, Wallace S., General Electric Company, Schenectady, N. Y.
Clegg, William, Jr., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Cook, C. S., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Davis, C. B., General Electric Company, Boston, Mass.
Davis, H. P., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Doran, W. S., Allis-Chalmers Company, Milwaukee, Wis.
Ellsworth, Jas. D., Michaelis and Ellsworth, New York City.
Emmet, W. L. R., General Electric Company, Schenectady, N. Y.
Emmons, E. E., General Electric Company, Schenectady, N. Y.
Feicht, R. S., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Felton, J. P., General Electric Company, Boston, Mass.
Fish, W. C., General Electric Company, West Lynn, Mass.
Foster, G. B., Allis-Chalmers Company, Chicago, Ill.
Fowler, W. F., Westinghouse Electric and Manufacturing Company, Baltimore, Md.
Gale, F. H., General Electric Company, Schenectady, N. Y.
Gaylord, T. P., Westinghouse Electric and Manufacturing Company, Chicago, Ill.
Gibson, John J., Westinghouse Electric and Manufacturing Company. Philadelphia, Pa.
Gilbert, E. E., General Electric Company, Schenectady, N. Y.

Giles, A. F., General Electric Company, Atlanta, Ga.
Gordon, J. R., Westinghouse Electric and Manufacturing Company, Atlanta, Ga.
Griffin, G. B., Westinghouse Electric and Manufacturing Company. Pittsburgh, Pa.
Griffin, General Eugene, General Electric Company, New York City.
Hale, General Irving, General Electric Company, Denver, Colo.
Hall, D., Allis-Chalmers Company, Cincinnati, Ohio.
Harris, Max, Nernst Lamp Company, Pittsburgh, Pa.
Harvey, L. M., Allis-Chalmers Company, Milwaukee, Wis.
Haskins, C. D., General Electric Company, Schenectady, N. Y.
Hillman, H. W., General Electric Company, Schenectady, N. Y.
Houck, H. C., General Electric Company, Cincinnati, Ohio.
Humphrey, C. B., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Hunting, F. S., Fort Wayne Electric Works, Fort Wayne, Ind.
Jeffrey, J. R., Allis-Chalmers Company, Milwaukee, Wis.
Johann, Charles S., Westinghouse Machine Company, Pittsburgh, Pa.
Knox, King H., Allis-Chalmers Company, Cincinnati, Ohio.
Lamme, B. G., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Lovejoy, J. R., General Electric Company, Schenectady, N. Y.
Macbeth, W. N., The Shelby Electric Company, Philadelphia, Pa.
Manson, D. E., Westinghouse Electric and Manufacturing Company, Boston, Mass.
Miller, M. C., Allis-Chalmers Company, Milwaukee, Wis.
Mullen, E. D., General Electric Company, Philadelphia, Pa.
Nicholson, S. L., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Nordstrum, L. D., Fort Wayne Electric Works, Fort Wayne, Ind.
Page, A. D., General Electric Company, Harrison, N. J.
Panteleoni, G., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Pardee, E. T., Allis-Chalmers Company, Boston, Mass.
Pevear, J. B., General Electric Company, Cincinnati, Ohio.
Pulver, G. W., Allis-Chalmers Company, Buffalo, N. Y.
Randall, F. C., Allis-Chalmers Company, Milwaukee, Wis.
Randall, K. C., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Rice, Calvin W., General Electric Company, New York City.
Rice, E. W., General Electric Company, Schenectady, N. Y.
Rice, R. H., General Electric Company, West Lynn, Mass.
Roberts, E. R., Nernst Lamp Company, Pittsburgh, Pa.
Rugg, W. S., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Scott, Chas. F., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.

Scribner, J., General Electric Company, Chicago, Ill.
Serva, A. A., Fort Wayne Electric Works, Fort Wayne, Ind.
Steinmetz, C. P., General Electric Company, Schenectady, N. Y.
Stone, C. W., General Electric Company, Schenectady, N. Y.
Stranahan, O. A., Allis-Chalmers Company, Milwaukee, Wis.
Strauss, M. A., Allis-Chalmers Company, Milwaukee, Wis.
Sunny, B. E., General Electric Company, Chicago, Ill.
Taylor, Frank H., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Thompson, G. L., General Electric Company, Philadelphia, Pa.
Tingley, E. M., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Vaughen, F. G., General Electric Company, Schenectady, N. Y.
Wagoner, P. D., General Electric Company, Schenectady, N. Y.
Warner, R. L., Westinghouse Electric and Manufacturing Company, Boston, Mass.
Whiteside, A. H., Allis-Chalmers Company, Philadelphia, Pa.
Whiteside, W. H., Allis-Chalmers Company, Milwaukee, Wis.
Wiley, James R., Standard Underground Cable Company, Chicago, Ill.
Willcox, Francis W., General Electric Company, Harrison, N. J.
Wirt, H. C., General Electric Company, Bryantville, Mass.
Wood, James J., Fort Wayne Electric Works, Fort Wayne, Ind.

OFFICERS AND EXECUTIVE COMMITTEE

Officers

Wm. H. Blood, Jr.	President
Arthur Williams	First Vice-President
Dudley Farrand	Second Vice-President
W. C. L. Eglin	Secretary and Treasurer
H. Billings	Asst. Secretary and Treasurer
Geo. F. Porter	Master of Transportation

Executive Committee

Elected at the Twenty-sixth to serve until the close of the Twenty-ninth Convention.

Louis A. Ferguson — Harry Bottomley
Alex Dow

Elected at the Twenty-seventh to serve until the close of the Thirtieth Convention.

Samuel Scovil — A. J. DeCamp
W. F. White

Elected at the Twenty-eighth to serve until the close of the Thirty-first Convention.

Charles L. Edgar — John Martin
Frank W. Frueauff

COMMITTEES

TO REPORT TO THE TWENTY-NINTH CONVENTION

Committee on Standard Rules for Electrical Construction and Operation

ERNEST H. DAVIS, Chairman

LOUIS A. FERGUSON — ALEX DOW

WM. BROPHY — SAMUEL SCOVIL

Committee on Relations between Manufacturers and Central Stations

HENRY L. DOHERTY, Chairman

A. C. DUNHAM — LOUIS A. FERGUSON

Committee on Relations with Kindred Organizations

JAMES I. AYER, Chairman

ARTHUR WILLIAMS — HENRY E. CLIFFORD

Committee for the Investigation of the Steam Turbine

W. C. L. EGLIN, Chairman

A. C. DUNHAM — W. E. MOORE

I. E. MOULTROP — J. D. ANDREW

Committee on Present Methods of Protection from Lightning and Other Static Disturbances

ALEX DOW, Chairman

O. A. HONNOLD — ROBERT S. STEWART

Committee on Rates and Costs

C. L. EDGAR, Chairman

LOUIS A. FERGUSON — FRANK W. FRUEAUFF

SAMUEL SCOVIL — P. G. GOSSLER

R. S. HALE

Committee on the Fire Hazard of Electricity

H. C. WIRT, Chairman

C. E. SKINNER — A. A. POPE

Committee to Co-operate with the Lamp Manufacturers on Advertising

PAUL SPENCER, Chairman

J. E. MONTAGUE — J. F. GILCHRIST

Committee on Public Policy

ARTHUR WILLIAMS, Chairman

SAMUEL SCOVIL — G. E. TRIPP

E. H. DAVIS — DUDLEY FARRAND

Editor of Progress — T. COMMERFORD MARTIN

Editor of Question Box — PAUL LÜPKE

ORDER OF BUSINESS

TUESDAY, June 5, 1906

MORNING SESSION, 10.15 A. M.

1. Address of Mayor Stoy
2. Address of President Blood
3. Announcements
4. Report—Committee on Progress. T. COMMERFORD MARTIN
5. Paper—"Mercury Arc Rectifier System with Magnetite Lamps for Street Illumination." By W. S. BARSTOW
6. Paper—"The Flaming Carbon Arc Lamp." By LOUIS B. MARKS

AFTERNOON SESSION, 2.20 P. M.

1. Report—Committee for the Investigation of the Steam Turbine. W. C. L. EGLIN, Chairman
2. Paper—"Mechanical Refrigeration." By JOHN MEYER
3. Paper—"Fuel Economy." By J. HENRY HALLBERG
4. Report—Electric Heating and the Residence Customer. JAMES I. AYER
5. Paper—"Line Construction for Overhead Light and Power Service." By PAUL SPENCER
6. Discussion on Mr. Marks' Paper (concluded)

MINUTES

OPENING OF THE CONVENTION

The twenty-ninth convention of the National Electric Light Association was held at Young's Pier, Atlantic City, N. J., June 5, 6, 7 and 8, 1906. President Blood called the meeting to order at fifteen minutes after ten o'clock Tuesday morning, June 5, and said:

Atlantic City is noted for two things—for its fine weather and for its hospitality. We have already seen what can be done for us in the way of fine weather, for we have had days that were apparently made to order. We are now about to accept the hospitality of the place. I have great pleasure in introducing to you the Honorable F. P. Stoy, the mayor of Atlantic City.

ADDRESS OF MAYOR STOY

Mr. Chairman, Ladies and Members of This Association:

I deem it a great privilege to be with you this morning, and I assure you it is a great pleasure. For many reasons we are pleased to have you with us in convention here, coming as you do from all parts of the country, and when I say we are pleased I speak for the resident people of our city. Coming as you do from all parts of the country, you naturally have expected when you reached Atlantic City to receive the right hand of fellowship and a hearty welcome. I am here to-day to extend to you that hearty welcome, but I regret very much that your number is so small at the beginning of your meeting. However, I am advised that in convention to-morrow you will number something like two thousand persons.

I want to extend to you a hearty welcome this morning and with it the freedom of the city. It is not expected that I shall deliver to you any lengthy address. You have the liberty of the town, and that seems to satisfy almost every convention that comes to our city.

To-day was the day set for the inspection of the police department. On account of this convention and of the fact that the parties who are making the uniforms are a little behind in their work, we have decided to hold the inspection to-morrow, so as to give the police a chance, if they should find you in distress to-day, to direct you to your right place. To-morrow, at the end of the inspection, when your convention is in full operation, we shall give them instructions exactly what to do—stating to them that you have come here to enjoy yourselves and to occupy places in the city that perhaps you would not be allowed to occupy if the police had full sway. We expect to give you all the liberty that can be extended to you in a city, and we hope that in addition to transacting the business of your convention you will find time to indulge in some of the diversions with which our city abounds; and I am glad to note on your programme that very liberal provision for this has been made by your committee on

arrangements. I notice that the ladies have a special day for an automobile ride into the country, and I trust they will enjoy that occasion very greatly. I want to assure the ladies that in their absence good care will be taken of the men.

I trust that all of those who come to our city during this convention will feel that they have had extended to them the hand of fellowship, and hope that while you are here to-day and while you continue your convention you will consider not only your present sojourn at Atlantic City and enjoy yourselves as fully as you can, but that when you are selecting a place for a convention in the future you will not forget that Atlantic City stands with its hands open to you and that the latchstring always hangs outside.

Now, Mr. President, I will not detain you with any further remarks. I thank you for your courtesy in inviting me here, and I trust you will enjoy a pleasant time with us.

Mr. Arthur Williams (New York City): Mr. President, permit me to move a vote of thanks from the association to his Honor, the mayor of Atlantic City, for the compliment he has paid us in coming here this morning and for the courtesies he has extended to us in his admirable address; and to include in this vote the common council of the city of Atlantic City for its courtesy in the illumination of the boardwalk, which, in view of the association's presence, began last evening. I take great pleasure, Mr. President, in making this motion.

(The motion was unanimously carried.)

President Blood then presented the following address:

ADDRESS OF PRESIDENT BLOOD

To the Members of the National Electric Light Association:

Gentlemen—It is with great pleasure that I call to order this, the twenty-ninth convention of The National Electric Light Association. To preside over this dignified assembly, composed as it is of the leaders of the electric lighting industry, the progressive manufacturers, the enterprising engineers and the successful salesmen, is a privilege highly esteemed by your president.

Last year we enjoyed the hospitality of the West, and the trip to Denver and Colorado Springs in special through trains was a feature of the gathering. This year you have come to the extreme East, where you may admire the Atlantic ocean with its tempestuous waves, and contrast its vastness with the royal splendor of the mountains you saw last year.

The association is to be congratulated upon its continued growth and prosperity. Two years ago, when we met in Boston, the total membership was 588. To-day we have nearly double this number, for we have enrolled 1024 members. The vigorous campaign for new members, inaugurated two years ago, has been continued in a less expensive manner but with most satisfactory results by our efficient assistant secretary and treasurer.

The question of annual dues should receive the prompt consideration of the incoming administration. It may be expedient to increase the fees of the companies operating in the largest cities. It is desirable, your president believes, to so adjust the dues in cities of 10,000 population or under that companies operating therein can not afford to stay out of the organization. We need the co-operation of just such members, and the affiliation with the stronger companies, through the association, will enable them to get information or assistance which if operating alone might be expensive, if not impossible, to obtain.

The Class C members—college professors—have received the careful consideration of your president during the past year,

and as a result of his investigations he unhesitatingly recommends that they be treated as an honorary class, that no fees be exacted and that they be admitted upon invitation only, and that each case be passed upon annually by the executive committee. We desire the fellowship of many earnest educators for their own sake and because of the influence which they have over the hundreds of young men they are sending out each year from the technical schools. On the other hand, this association has no place for the instructor, with only academic ideas as to corporate management, who in his capacity as consulting engineer either ignorantly or wilfully misrepresents the facts.

In 1904, President Edgar called your attention to the construction of the Union Engineering Building founded by Mr. Andrew Carnegie, which was to be built on Thirty-ninth street, New York City. This building is now nearing completion and your executive committee has agreed to take quarters in it as soon as it is finished, which will be within a few months. The present offices of the association are crowded, and by our removal to this location we shall be identified with that which is sure to become the greatest centre of engineering life in this country, if not in the world.

Our relations with the Underwriters have, during the past year, been pleasant, partly because there has been no question at issue between us and also because we are becoming better acquainted with each other. The policy of having a representative of the association devote the larger portion of his time to insurance interests and to settling differences between the members of the association and the Underwriters has been approved by the executive committee and is now referred to the incoming board for early action.

It is my pleasure to call your attention to a new feature of this meeting. It has been the custom, heretofore, for the association to wait for invitations before making the choice of a convention city. Early this year the executive committee decided that by making its own selection, rather than by looking to the local company for the financing of the meeting, the association would be more independent and the holding of the convention would not be a burden to any city.

For many years the manufacturing companies and others have had small exhibits in rooms scattered throughout the hotels.

This year we are trying an experiment of having a central exhibition hall and, from the interest shown in it by the manufacturers and from the attractive displays which they have made, I think we may well call it a success, A novel attraction of this exhibit is, the central-station advertising display, which tends to emphasize the fact that "business getting" is one of the important parts of the successful electric lighting enterprise.

The year has shown a healthy growth of the electric lighting business, but it is not notable as having given birth to any marked innovation in the physical part of the business. The size of generating units continues to increase, distribution by high-tension alternating current is becoming more and more general, and minor improvements all along the line are extending the utility of this system. Undeveloped water-powers, which a few years ago were valueless, are to-day being eagerly sought out and, by means of improved water-wheels and high-tension lines, are being made available for large sections of the country. Gas engines, steam turbines and other prime movers are receiving the careful attention of enterprising engineers, because we are all beginning to realize, more and more forcibly each year, that the great losses between the coal pile and the dynamo must be cut down.

There has been a marked increase in centralizing the ownership of electrical undertakings. This has benefited the communities served, by bringing to their service better managerial as well as improved operating methods. This centralization is causing electrical managers to look more closely to their markets, and to-day the company that has not a new-business-getting department is sadly behind the times.

For many years by far the largest portion of the manager's time was spent in trying to better the physical condition of his plant and in reducing operating expenses to a minimum. To-day he is reaching out to supply all possible demands and through his corps of trained solicitors is endeavoring to load the plant with long-hour users of current, thus giving to the customer a low rate, while the company is better enabled to make a fair return upon its investment.

Allied with the question of rates is the problem of government supervision or regulation. This matter is demanding serious consideration at the present time. Witness the Massachusetts

Gas and Electric Light Commission, which has been in existence several years, the newly-formed New York State Lighting Commission, and the bill just passed by the Massachusetts Legislature adopting the English automatic method of control called "The Sliding Scale System."

A study of the municipal undertakings in Great Britain and the constantly growing list of municipal failures in the United States shows that municipal ownership is, in fact, no longer as popular as it once was. Some agitation, however, is being kept alive by the socialist, by the unscrupulous political agitator and by the "yellow journal," whose whole fabric is based upon class hatred, whose teachings are that all riches come through stealing from the poor and whose very existence depends upon its ability to pervert the facts and to "fake" reports so as to make interesting reading for that part of the public loving sensation.

The proper treatment for the wilful perversion of public opinion by the press is a difficult problem. Our laws as to the deliberate publication in newspapers of false and wilfully misleading statements are not sufficiently severe. However, there still remains a powerful antidote in the hands of the public. The main support of the newspaper is its income from advertising. Its value as an advertising medium depends upon the quality and quantity of its circulation, and if those who advertise will exercise a healthy discrimination between those journals whose policies and performances are calculated to promote or to destroy the interests of their advertisers, the power for evil of some of them will be reduced.

A general reduction in price for current and a readjustment of rates is constantly taking place all over the country. Flat rates are fast becoming things of the past, and wattmeters, in conjunction with various kinds of demand systems, are now almost universally used. Although the public has been for years trying to understand the demand system of charging, it still objects to it, and there is a feeling in some quarters that we may have to return to the straight meter rate, which, although admittedly unjust and unfair, still has a decided advantage in its simplicity.

Along with the general reduction in rates is a lowering of the charges for street lighting, and in this connection let me remind you that the lower this rate is the less liable are you to be

disturbed by municipal ownership agitation or by competition of any kind.

It is an unfortunate fact that, from time to time, we see in the public press erratic and even false assertions in regard to electric lighting properties. Public speakers also are altogether too prone to make unwarranted statements. Let us be more active, more aggressive to refute these unwarranted charges, and by voluntary publicity of the facts as to our properties, by fair rates, and by straightforward dealings with those in authority and with the public, show to all people that the electric lighting business of the United States is done "on the square."

ANNOUNCEMENTS

Secretary Eglin announced that the following-named associations had accepted invitations to send representatives to the meeting:

Ohio Electric Light Association.
Northwestern Electrical Association.
American Street Railway Association.
Association of Edison Illuminating Companies.
Underwriters' National Electrical Association.
Kansas Gas, Water and Electric Light Association.
Canadian Electrical Association.
Underwriters' Laboratories.
National Board of Fire Underwriters.
Southwestern Electrical and Gas Association.

The secretary stated that he had received letters of regret at their inability to be present from past-presidents Weeks, Doherty and Edgar.

An invitation to attend the meeting of the Illuminating Engineering Society on June 8 was read.

THE PRESIDENT: We will now proceed with the regular programme of papers. The first business is the report of the committee on progress, and I take pleasure in introducing Mr. T. Commerford Martin.

MR. MARTIN: The report of the committee on progress covers a great variety of subjects, included this year under seventeen separate heads. I do not know that the paper contains anything particularly new or anything that you could not have acquainted yourselves with had you read the electrical journals during the past year. That I presume you have done carefully in the intervals of central-station management. The chief item of statistical interest is that with regard to the development of our industry, showing that within the past year some 600 new central stations have gone into operation, a rate of progress that has not been equaled in any year since the electric light became a subject of commercial development. An increase of 15 per cent over 1904 would bring the investment in our industry up to the magnificent total of $700,000,000, a figure hardly equaled in any other public service development in this country or anywhere else. The gross earnings upon that investment are estimated at $135,000,000 from the sale of current and the expenses at $95,000,000. The industry is thus shown to be upon a fair basis of profit, but is obviously not yielding anything that is excessive as a return for the investment and the care and attention that are necessary for its management.

The report also states for the first time that the production of electrical apparatus in this country for 1904, the latest figures available, reached the enormous total of $157,000,000, nearly $100,000,000 of which was consumed in our own branch of the electrical industry.

I do not know that I need call your attention to the various subjects treated in the report, as you can read the paper at your leisure. The report touches on the newer forms of illumination, such as the flaming arc, which your committee had the honor of bringing to your notice some three years ago. Data are also given with regard to vapor lamps, Nernst lamps and the newer forms of incandescent lamps, particularly those of the metallic --not metalized, but the metal-filament—type. Several of these are enumerated and data given in regard to them.

A rather interesting note is made with regard to the com-

bined pole lines in Los Angeles. Some details are given of the scheme, but the manager of the lighting system in that city advises me that, while it is hoped to put this system in early operation, it is not yet effective.

The report closes with one or two suggestions with regard to co-operation in respect to running down accident swindles, which are such a pest; also with regard to watching the work of state associations, and, further, in regard to co-operation in respect to the standardization of electrical apparatus and of electrical current throughout the world, so that here and in Europe, and elsewhere, we shall use apparatus answering to the same description and the same tests, and we shall also all use apparatus that is fitted to the same voltages and to other conditions of current, enabling us to carry around the world the apparatus that we have already made effective upon our circuits at home.

One more point, Mr. Chairman—you have referred to the work of the committee with respect to central-station advertising. Last year your committee was encouraged to make a tentative exhibit of central-station material at Denver. It was very interesting to see the attention that was immediately aroused by that very haphazard and crude experiment. This year your committee, with the co-operation and generous assistance of some fifteen or twenty of the larger and smaller companies, has made an exhibit to which it desires to call your very serious and earnest attention. You will agree with me that to-day the gaze of the central-station manager is no longer turned inward, but is being turned outward. He has ceased to study and consider himself alone, and is beginning to study his patrons and customers. The result of this has been what we can term nothing else than the renaissance of electric lighting in the United States. The exhibit your committee is making of central-station materials, posters, placards, bulletins, dodgers, circulars and follow-up letters, is, all of it, well worthy your attention, and I sincerely trust that none of you will go away without giving that exhibit at least as much attention as you are able to give to any other.

The following is Mr. Martin's report:

REPORT OF THE COMMITTEE ON PROGRESS

A NEW POINT OF DEPARTURE

The year 1905 would appear to mark the beginning of a new period in the development of electric light and power in the United States. It would be difficult to define the nature of the change briefly. Perhaps it is safe to sum it up in the statement that the central stations of the country, realizing the cumulative effect of the reductions in the cost of producing and supplying electricity to the public, had united upon a commercial propaganda to sell the cheaper current thus rendered available. The gaze and the study of the manager were turned outward rather than inward. For several years previous a process of consolidation had been going on actively. In most cities the service had become unified financially and physically under one management. Elsewhere, large sections of individual states had undergone the same centralization of the sources of electrical supply. Beyond this, numerous plants, scattered all over the country, ill-constructed, poorly run, badly financed, had become subject to a common ownership or operation in highly competent hands. Thus, while technical changes and improvements did not cease, the interest shifted very manifestly from the engineering to the commercial side of the industry, and at the present moment this newer situation is still developing. The central-station manager has within the last two years received more advice as to the sale of his current than he endured as to its manufacture in the whole previous twenty. Probably no body of men ever before found themselves the subject from the outside of so much uninvited instruction as to how they should run their own business; and it is natural that they should find themselves bewildered by the multitude of their counsellors. Presently they will discover that no great harm has been done, but that, on the contrary, huge benefit has sprung from this convergence on their field of the experience derived from salesmanship in so many other branches of industry. Lava has ere now proved itself a good fertilizer, and earthquakes afford an excellent excuse for building anew. It may be asserted without the slightest fear of contradiction that the

industry has been revivified by the "publicity" campaign of recent date, that it has ceased to minister to the comfort of the many in order to meet the necessities of the million, and that it has made splendid advances toward the accomplishment of its universal purpose and potentialities. The manifestations of this new period have been numerous and various, and one of the most encouraging has been the growth of this association. Another has been the activity displayed by territorial and state associations and the creation of new ones, notably that in New York State. A third evidence has been the interest displayed by the manufacturers in fostering new business, exemplified by the Coöperative Electrical Development Association. Yet a fourth has been the devotion by the technical press of a large share of attention and space to what is after all a matter quite without technical or engineering importance, *viz.*, discussions of the art of selling and of winning the public eye and ear—in this instance for electrical current and apparatus, though virtually all the arguments and most of the practice would apply to the sale of beer or beef. It is improbable that undue emphasis can be long maintained by all or any one of these agencies, but the present effect of arousing energies that languished is of tremendous benefit; and an outlook that was rather discouraging during 1903-4 has brightened to such an extent that only the best auguries can be formed and entertained as to the future.

DOMESTIC STATISTICS

It is customary for your committee to present in this report on progress a few general statistics as to the growth of the industry during the year. This is always a helpful basis of comparison, and in the present instance is very encouraging. The increase in the number of central-station plants of all kinds has been maintained in step with the growth in population and wealth. It was estimated in this report last year that there were 4200 central-station enterprises. The current issue of the authoritative *Central Station List* for the first quarter of 1906 contains the names of 4839 plants, of which 3732 were under private and corporate management and 1107 were municipal. The gain in six months had been 301 plants, or 600 for the year, a very close proof of the maintenance of a steady and high rate of increase. While of these new plants in the first half of 1905-6 no fewer than

48 were in Texas, the older states were notably leaders in activity, Pennsylvania accounting for 21 and New York for 18, Ohio and Michigan for 15 each.

An increase of 15 per cent over 1904 would bring the investment in distinctive central-station plants up to $700,000,000 in 1905. The gross earnings are estimated at $135,000,000, expenses on which at 70 per cent would amount to $94,500,000. As a matter of fact, the output of current was everywhere much larger than ever before, but the rates obtained were frequently much lower than ever before. Throughout the whole country the wave of feeling against corporations and the "craze" for municipal plants did much to put companies on the defensive and apologetic basis, and in too many instances the kilowatt-hour price was cut to the danger point. In fact, it is not yet sure that all the companies which have reduced rates under compulsion or in a weak moment of panic can endure the strain. Time will show, and it can only be hoped that the temptation thus held out to use more electricity, supplemented by the vigorous and even desperate advertising campaign, may have helped to produce the result of so increasing sales on the lower margin of profit that obligations and fixed charges can be met and a satisfactory balance sheet be shown.

The production of apparatus and supplies for central-station circuits and isolated plants may be inferred or estimated from the figures of 1904 just now made public by the United States Census Bureau. These are interesting and are the latest statistics available. The total output of all strictly electrical apparatus for that year was valued, at the factories making it, at $157,949,514. Specific items were as follows: 15,130 dynamos of 1,328,243 horse-power, value $11,084,234, and $1,740,534 of dynamotors, motor-generators, and so forth; transformers worth $4,468,567; 79,877 motors of all kinds of 678,910 horse-power worth $22,370,626; storage batteries worth $1,977,435; lighting carbons worth $1,050,971; arc lamps to the number of 194,757 worth $1,574,422; incandescent lamps and parts worth $8,964,065, of which lamps over 83,000,000 were of 16-cp.; electric light fixtures worth $3,294,606; insulated wires and cables worth $34,519,699; electric conduits worth $2,416,245; rheostats and resistances valued at $1,328,752; measuring instruments valued at $5,004,763. These items account for a large proportion of the total and show to what an extraordinary degree modern electrical development is based

upon dynamo current as furnished from power plants and upon such agencies as the motor and the lamp. The figures when studied reveal also notable changes in branches of the art. Thus the dynamos reported, while worth only $600,000 more than those of the year 1900, were nearly 600,000 horse-power greater in capacity, showing how the larger units have tended to reduce the cost per horse-power. In arc lamps only 1748 were of the open type, whereas in 1900 some 23,656 were made; the figures of to-day indicating that unless newer types of it "make good" the open arc must soon disappear entirely from the field where it once reigned supreme. The increase in sign lighting is indicated by a fivefold increase in the number of miniature and decorative lamps in the four years.

FOREIGN DATA

An interesting basis of comparison is that afforded by foreign countries, and of these two have available statistics, *viz.*, England and Germany. Other European nations do not yet compile their figures as to electric light and power in annual or convenient form, although occasionally eloquent testimony as to American methods and results is significant in the absence of precise data. Thus Paris is familiarly spoken of as *La Ville Lumière,* but to the American central-station eye it is far from justifying the appellation. A distinguished French journalist who visited the United States recently found, naturally, much unloveliness, but as to the lighting of New York the following tribute escaped him almost involuntarily:

> I was at the centre of the river. There is no twilight in this country. Night falls immediately. Already the lights were shining on the New York side. For a long time I gazed at the rows which were lighting up as if by enchantment. Presently a magnificent sight spread itself out before my eyes. And this was the first sensation of true beauty that I had found in America, but so powerful and so grandiose! On my left the whole town is lit up. Night has suppressed the architecture; one sees no longer whether the houses are ugly or not. Only hundreds, thousands, one might say millions, of little squares of glass glitter from earth to sky. Scores of rows of lamps extend side by side until lost to sight. The very smallest houses, surpassed by the larger, themselves dominated by those higher still, give one the impression of a colossal perspective, like a giant climbing toward inaccessible heights. One has the vision of innumerable palaces *en fête! Paris seen at night from the heights of Montmartre has nothing to compare with this!* One would say that all the stars of the sky, more intense, had suddenly come to group themselves symmetrically 300 yards away. The colossal and the immeasurable arrive at beauty, a beauty which is titanic, crushing and splendid. And this profound impression of beauty which arises from the very number of these fires, from the mathematical order of their lines, imposes itself against every rule of æstheticism and art; it is force, incal-

culable energy, from which there is born a powerful and precious emotion. I remained stupefied with surprise and joy, and I left with regret, sorry to abandon this new emotion, which I was afraid of losing, as though it were a dream which awakening would chase away.

Turning from this tribute as to the contrast between Paris and New York, the figures for England may be first noted for the year 1905. They are those of 262 distinct electrical supply plants, without trolley load, although this is far from doing justice to the lighting end of the art, as there are also no fewer than 122 stations with both lighting and tramway load. In the United States, however, there are more than double this number of trolley roads that do a light and power business with an income of several million dollars a year. The number of new stations in progress was small; largely accounted for by the increasing number of districts in which supply is taken "in bulk" from a large power-house outside the area. With regard to the system of distribution there is little change; three-wire direct-current at about 220 and 440 volts continues to hold sway. With regard to generating plant the increasing use of the steam turbine, especially for alternators of large size, is very noticeable. A few have installed gas-driven plants, but only in connection with small units. There is an almost universal reduction in the amount and price paid for coal, which is partly due to the further perfection of automatic stoking appliances which enable the use of cheaper qualities of coal. The steady reduction in the price charged for lighting supply has continued, but the decreased charge is more marked in the case of supply for power and heating. A number of the London companies, for example, supply energy for this purpose at two cents per kilowatt-hour. Notwithstanding the keenness of the competition of gas lighting, the increase in electric street lighting is well maintained and numerous Nernst lamps have been installed during the year. The new metallic-filament lamps are beginning to make their appearance in the streets, and in several places the flame arc has been introduced. The connections to the circuits show 417,000 kilowatts of direct current, 132,500 kilowatts of alternating and 480,400 kilowatts of mixed, a total of 1,029,400 kilowatts, of which 247,100 kilowatts are in London and 782,300 kilowatts in the provinces. A motor load is shown of 248,900 kilowatts.

It would appear from "Garcke's Manual," an excellent guide to British electrical investment, that the companies devoting them-

selves to electric light and power employ $160,000,000 of capital, and that the returns reported by 187 companies show 5.57 per cent on the ordinary capital, 5.14 per cent on the preferred stock and 4.53 per cent on the bonded investment, or an average of 5.11 per cent. In addition there were 277 municipal plants employing $177,000,000 of capital. An interesting comparison was recently made public as to the results enjoyed by the public under this régime where the municipal ownership investment preponderates. In England there are no cities of over 300,000 population supplied by private plants, except London, where the city is divided into districts. In cities of from 150,000 to 300,000 population, all except one are supplied by municipal plants. The figures in the following table show population, connected load of private lamps (8-cp), connected load of private motors (hp), number of consumers and miles of main, from the London *Electrician* sheet for 1904-5; kilowatt-hours sold to private customers and average price to private customers. Newcastle, the only one of these towns supplied by private enterprise, was largely freed in 1900 from the tax involved by the purchase clause.

	Population (Approximate)	No. of Private Lights of 8-cp	Private Motors, h. p.	No. of Consumers	Average Price to Public, Excluding Trams and Street Lighting	Thousands of k.w.h. Sold to Public
Public plants—						
Dublin	289,000	82,000	220	850	3.58	857
West Ham	267,000	84,000	670	1,004	3.13	1,827
Dundee	163,000	72,000	715	1,030	3.52	1,073
Leicester	220,000	156,000	167	2,240	3.83	1,719
Salford	220,000	122,000	2,685	1,000	2.62	2,051
Aberdeen	165,000	107,000	1,871	1,321	3.65	1,581
Cardiff	164,000	62,000	607	1,079	3.27	1,736
Nottingham	239,000	206,000	1,913	2,704	2.08	7,937
Private plants—						
Newcastle	217,000	288,000	6,650	4,160	{ 1.66 / 2.50	11,684

* Two companies in separate district, *i. e.*, without competition.

Freed from the purchase clause, private enterprise has given the lowest prices, the municipal price averaging nearly 75 per cent higher. In proportion to population private enterprise supplies nearly double the number of consumers reached by the most enterprising municipality, and fully three times as many as the average municipality. Private enterprise supplies nearly as much electric energy to motors as all the eight municipalities put together. It is curious that when every English municipality

has had for twenty-two years all the advantages that the Newcastle company has had for only four years, not one of them shows as good a record of benefit conferred upon the public.

Germany is the next, and, indeed, only other European country presenting authentic statistics of value in this country, and the figures available date to April 1, 1905, when there were 1175 plants in operation and 540 in process of construction, if the reports be true, although that seems an almost incredible proportion between old and new enterprises for a single year. Since that time one-third of the projected plants are said to have gone into operation, making the present number about 1500. The development of German central stations in the last 10 years is shown in the following table:

	Number of Plants	Number of 50-Watt Incandescent Lamps	10-Ampere Arc Lamps	Motors H.P.
1894	148	493,801	12,357	5,635
1895	180	602,986	15,396	10,254
1897	265	1,025,785	25,024	21,809
1898	375	1,429,601	32,586	35,867
1899	489	1,940,744	41,172	68,629
1900	652	2,623,893	50,070	106,368
1901	768	3,403,205	64,278	141,414
1902	870	4,200,203	84,891	192,059
1903	939	5,050,584	93,415	218,953
1904	1,028	5,687,382	110,856	263,[illegible]36
1905	1,175	6,301,718	121,912	310,428

Of the 1175 stations in operation on April 1, 1905, there were 929 using direct current with accumulators with a total capacity of 313,058 kilowatts. The direct-current system without accumulators was used by 44 plants; their total capacity was only 2960 kilowatts. Single-phase and two-phase alternating-current systems were used in 43 stations of together 39,178 kilowatts; three-phase current in 75 stations of together 89,306 kilowatts; the monocyclic systems in two stations with 1182 kilowatts; the combined three-phase and direct-current system was used in 66 stations of 170,536 kilowatts, while the combined single-phase or two-phase alternating-current and direct-current system was used in 16 stations of together 9650 kilowatts. The total capacity of the 1175 stations was 625,870 kilowatts; these plants were located in 1133 different localities. More than one-half, namely, 630 stations, use steam, and their capacity (411,716 kilowatts) is four-fifths of the total capacity of all central stations, if accumulators are not included in the capacity figure. There are 125 water-power stations with a total capacity of 15,582 kilowatts. Gas power

is used in 124 stations with 11,120 kilowatts. Both water and steam power is used in 219 stations of 61,692 kilowatts; both water and gas power in 18 stations of 1572 kilowatts; both steam and gas in 20 stations of 5167 kilowatts. The number of incandescent lamps connected on April 1, 1905, and reduced to 50-watt lamps was 6,301,718; the number of 10-ampere arc lamps was 121,912, the capacity of all motors was 310,428 horse-power. The total connections, reduced to 50-watt incandescent lamps, represented 13,108,542 incandescent lamps, or 655,427 kilowatts. The number of electricity meters in use was 269,722. It appears that the flat rate with discounts is used in a majority of cases. As a typical example the central station of Aix la Chapelle may be mentioned, which charges for energy for lamps 13.75 cents per kilowatt-hour for the first 250 hours and 6.25 cents for every further kilowatt-hour. For motors the following rates are used: During the day for the first 5000 kilowatt-hours 3.75 cents is charged per kilowatt-hour, 3 cents for the next 5000 kilowatt-hours, 2.5 cents for the next 10,000, 2 cents for the next 20,000 and 1.5 cents for every kilowatt-hour above that. For the evening hours the following motor rates are charged: If up to 10,000 kilowatt-hours are used daily, 7.5 cents are charged per kilowatt-hour; 6.25 cents between 10,000 and 20,000, 5 cents between 20,000 and 40,000, 4 cents between 40,000 and 80,000, 3.5 cents between 80,000 and 150,000, 3.25 cents between 150,000 and 200,000, and 3 cents for every kilowatt-hour above that. In addition to this rate of charging, which is most generally used in Germany, the double rate and the maximum demand are used in a large number of works, while quite a number of plants—and not only small ones—supply energy on a general flat rate. In 1905 there were 53 central stations with a capacity of more than 2000 kilowatts, their aggregate capacity being 330,203 kilowatts. These 53 plants are located in 40 cities. The five largest are the Berlin Electricity Works (three-phase and direct current, with accumulators), 91,971 kilowatts; Berlin Moabit (three-phase and direct current, with accumulators), 30,078 kilowatts; Berlin Oberspree (three-phase and direct current, with accumulators), 27,131 kilowatts, and Rheinfelden, which is the largest German hydroelectric station (three-phase and direct current, with accumulators), 14,491 kilowatts.

The Berlin central-station enterprise compares favorably with

any American system, particularly as to development on other than lighting lines. On June 30, 1905, 12,549 electric motors with an aggregate capacity of 40,912 horse-power were connected to the mains. They were used for the following purposes: Ventilators, 1868 motors (601 horse-power); presses, 1730 (5005 horse-power); metal-worker shops, 1775 (7551 horse-power); elevators, 1698 (9704 horse-power); wood-worker shops, 1241 (4751 horse-power); butchers, 678 (3394 horse-power); grinding and polishing machines, 376 (1390 horse-power); paper cutters, 369 (1140 horse-power); pumps, 252 (906 horse-power); sewing machines, 229 (201 horse-power); cloth cutters, 194 (140 horse-power); laundries, 230 (672 horse-power); spooling machines, 96 (274 horse-power); leather-worker shops, 111 (417 horse-power); electroplating shops, 75 (239 horse-power); for driving dynamos, 76 (809 horse-power); for grinding and roasting coffee, 78 (153 horse-power); for cleaning hats, 27 (74 horse-power); for miscellaneous purposes, 1446 (3491 horse-power). For the year 1904-5 there was an increase of 1937 electric motors having a total capacity of 6132 horse-power.

The financial results of German operation are not very clearly obtainable, but appear to be set forth in an analysis by Dr. Hoppe for last year in the following table:

			Lighting Rate per Kw-hour			Power Rate per Kw-hour			Average "Surplus" in Per Cent of Capital Invested
			= 15c.	Above 15c.	Below 15c.	Above 5c.	= 5c.	Less than 5c.	
Over	5000 Kw		—	12.0	8.6	6.7	10.1	—	10.5
Between	2000 and	5000 Kw	13.8	11.8	11.9	14.2	12.1	9.6	12.4
	1000	2000	11.6	6.9	5.2	8.5	9.2	4.7	8.0
	500	1000	8.0	9.1	7.6	8.9	7.8	8.7	8.4
	250	500	—	7.9	7.3	8.4	3.2	6.3	7.6
	100	250	6.4	6.1	4.8	7.9	4.2	4.0	5.5
Below	100 Kw		—	4.4	3.8	3.1	4.2	—	3.9

It would be justifiable to remark that neither in the United States nor Germany nor England does the central-station industry yet prove, except in individual cases, to be very profitable. The potentiality is there, but it is undeveloped and will probably remain so until the weight or direction of effort is shifted and it becomes rather a daylight business than one merely for a few dark hours nightly.

NEW CENTRAL-STATION WORK

The central-station practice followed in America during the past year has been conservative as to power-plant design, although experimental and revolutionary as to lighting apparatus on the circuits. It may be doubted if any member company can be cited as offering a novelty in its power-house design and construction. Indeed, the most startling novelty in this direction is the criticism made by the well-known English engineer, Mr. C. H. Merz, to your committee, that American central stations, especially such as those in New York, Boston and Chicago, were far too solid and "architectural," and did not admit of flexibility or extension and modification as to size and style of equipment. When an Englishman objects mildly to Yankee work on account of its stability and pretensions to beauty, it would seem that some prejudices on the score of the fragility and insecurity of construction on this side of the Atlantic have been outlived or have become outworn. No sweeter eulogy could fall on American ears than this criticism, but as one looks the country over and sees the numerous ramshackle plants, the unkempt circuits, the disreputable pole lines and the dusty lamps, it is realized that a long exposure would be less pleasing than was a "quick-shutter" effect.

The New York Edison Company is locating a huge new Waterside No. 2 right alongside No. 1 on the East river with a capacity 30 per cent greater than its predecessor. The next and third big plant in this system will be far to the north, the rapid growth of the city being wholly in that direction, but it might have seemed logical and preferable to erect No. 2 on the North river, on the west shore of Manhattan, so that no trouble on the east side of the city or *vice versa* could possibly paralyze the whole system. But it is significant to note that the whole present huge capacity is virtually bunched at one point, thus realizing Mark Twain's injunction, "Put all your eggs in one basket, and watch that basket." The management decided that there was no advantage to be gained in the selection of a site for No. 2 far removed from No. 1, while a close juxtaposition would secure many advantages from interconnection and the utilization of apparatus both on the electrical and on the steam end. Apparently, unified supervision counted for as much as anything else. The new plant is laid out for ten steam turbine generating equipments of seven to eight thousand kilowatt capac-

ity each, thus giving a total of over 100,000 horse-power with a 50 per cent overload capacity of over 150,000 horse-power; and the initial plant consists of four such units, two vertical and two horizontal. The maximum peak load the coming December will be above 60,000 kilowatts, and the connected load last August was nearly 3,500,000 in 16-cp equivalents. Such figures give a rough idea of the magnitude possible to a modern central-station enterprise and of the plant and investment required. No. 1 Waterside was, it may be noted, laid out only a few years ago for reciprocating engines, but has one or two turbines; while the new No. 2 is wholly of the turbine type of generating outfit.

A notable development in the generation of current has been the resort in San Francisco to very large gas engines by the California Gas and Electric Corporation, referred to briefly in last year's report. These three 4000-kw "Snow" engines, connected to Crocker-Wheeler generators, have the following dimensions: Length over all, 70 feet; width over all, 34 feet; weight of heaviest casting, 60 tons; diameters of cylinders, 42 inches; length of stroke, 60 inches; main journals, 30 inches; diameter, 54 inches long; main cross-head gibs, 27 inches wide, 54 inches long; diameter of centre of shaft, 38 inches; weight of flywheel, 130,000 pounds; total weight of engine, flywheel and generator, 1,200,000 pounds. In general design and detail they resemble modern high-grade, massive American steam engines. They are horizontal, twin tandem, double-acting four-cycle, giving two impulses to each crank per revolution. Any cylinder head can be removed by simply disconnecting a jacket water supply pipe and removing the nuts holding the head to the cylinder. All working parts are above the engine-room floor. The water supply, gas, air inlet and exhaust pipes are below the floor, and these are arranged so that they can be trenched. All the main parts have their proper relative positions positively and permanently fixed by male and female centering fits of large diameter, thus practically ensuring self-alignment. Lubrication of the cylinders is effected by spreading and by leading four oil feeds from individual oil pumps to each cylinder. The oil is fed to the cylinder on the inhalation stroke and is spread on the compression stroke. The lubrication of the journals is effected by means of a positive feed lubricator. Each oil feed is carried to the part to be lubricated by small tubing from a multiple feed oiler containing a

small oil pump for each feed led therefrom. The feed to each part is positive and can be adjusted to give a fixed supply of oil per revolution of the engine. When the engine stops the oil feed stops, and when the engine starts the oil feed also starts. Inlet valves, mixers and cut-off valves are so designed that gasolene can be injected to the surface necessary to be cleaned, rendering the dislodgment of any deposit an easy matter without removing the parts. The pistons are carried by crossheads, thus reducing materially the weight carried on the bore of the cylinders. By the use of three crossheads the main, intermediate and outboard, proper alignment of the pistons is possible, it is said, after years of service. Close regulation mechanically and electrically is expected.

Mr. W. H. Patchell, chief engineer of the Charing Cross Company, of London, who visited this country last year, is sponsor for a very interesting station described recently by him before the British Institution of Electrical Engineers. It is not a small plant at all, being of 16,000-kilowatt capacity, but the three-phase generators are designed to deliver 10,000 volts directly without transformers. The energy from the generators is transmitted by underground cables to substations, main transformers have been eliminated, and the 10,000-volt current is fed directly to motors direct-connected to the direct-current generators, synchronous motors being employed for the purpose, chiefly, with one or two induction motor sets also in each substation. There are four substations. All the motors take the full pressure of 10,000 volts, with a uniform motor size of 500 horse-power.

In connection with power-house work, it deserves note that before the American Institute of Electrical Engineers in January Mr. H. G. Stott read a striking paper on power plant economics, giving a complete analysis of the losses in a power plant from the coal to the 'bus-bars. The accompanying table shows the results obtained from such an analysis of the losses in a year's operation of the great Interborough plant under his direction as superintendent of motive power, one of the most efficient plants in existence to-day. He showed that the present type of power plant using reciprocating engines can be improved in efficiency as follows: Reduction in stack losses, 12 per cent; reduction in boiler radiation and leakage, 5 per cent; reduction in engine losses by the use of superheat, 6 per cent. Thus the

net increase of thermal efficiency of the entire plant would be 4.14 per cent, increasing the total thermal efficiency from 10.3 per cent to 14.44 per cent. He also presented curves to show that the best economy on dry saturated steam with steam turbines is practically equal to that of the reciprocating engine, and that 200 degrees superheat reduces the steam consumption 13.5 per cent. The shape of the specific consumption curve, however, is much flatter than that of the reciprocating engine, so that the all-day efficiency of the turbo unit would be considerably better than that of the reciprocating engine, with the other great advantage of costing approximately 33 per cent less for the combined steam motor and electric generator. The expansion is relatively more nearly adiabatic in the low-pressure stage of the turbine than in the low-pressure cylinder of the engine, so that it has been proposed that the reciprocating engine should be run high-pressure where relatively it is more efficient than the steam turbine, utilizing the turbine for the low-pressure part of the cycle. In other words, each should be used where it is most efficient.

ANALYSIS OF THE AVERAGE LOSSES IN THE CONVERSION OF ONE POUND OF COAL INTO ELECTRICITY

	B. T. U.	Per Cent	B. T. U.	Per Cent
1. B. t. u. per pound of coal supplied	14,150	100.0		
2. Loss in ashes			340	2.4
3. Loss to stack			3,212	22.7
4. Loss in boiler radiation and leakage			1,131	8.0
5. Returned by feed-water heater	441	3.1		
6. Returned by economizer	960	6.8		
7. Loss in pipe radiation			28	0.2
8. Delivered to circulator			223	1.6
9. Delivered to feed-pump			203	1.4
10. Loss in leakage and high-pressure drips			152	1.1
11. Deliveries to small auxiliaries			51	0.4
12. Heating			31	0.2
13. Loss in engine friction			111	0.8
14. Electrical losses			36	0.3
15. Engine radiation losses			28	0.2
16. Rejected to condenser			8,524	60.1
17. To house auxiliaries			29	0.2
	15,551	109.9	14,099	99.6
	14,099	99.6		
Delivered to 'bus-bar	1,452	10.3		

In discussing the gas engine Mr. Stott stated that the record of operation of several important installations of gas engines in power plants abroad and in this country seems to indicate that only one important objection can be raised to this prime mover, and that is that its range of economical load is practically limited to between 50 per cent load and full load. He suggested that the combination of gas engines and steam turbines in a single plant

offers possibilities of improved efficiency, while at the same time removing the only valid objection to the gas engine. A steam turbine unit can easily be designed to take care of 100 per cent overload for a few seconds; and as the load fluctuations in any plant will probably not average more than 25 per cent with a maximum of 50 per cent for a few seconds, it would seem that if a plant were designed to operate normally with 50 per cent of its capacity in gas engines and 50 per cent in steam turbines, any fluctuations of load likely to arise in practice could be taken care of. By utilizing the waste heat in the gas engines for the purpose of assisting to make steam for the turbines, there can be saved approximately 37 per cent of the total heat lost in the gas engine. Mr. Stott held that an internal-combustion engine plant in combination with a steam-turbine plant offers the most attractive proposition for efficiency and reliability to-day, with the possibility of producing the kilowatt-hour for less than one-half its present cost.

CENTRAL-STATION EMPLOYEES

Equal in importance with the efficiency of the apparatus in central stations is the efficiency of the employees, and it may be questioned whether all the necessary thought is always given to the training of the staff. A very interesting paper on the subject was presented last fall before the Association of Edison Illuminating Companies by Mr. W. F. Wells, now of the Brooklyn, then of the New York, Edison Company, with whose station force it dealt. As the great system referred to increased in size and complexity, and the service from each station became more and more interdependent, it was found necessary to broaden the organization and to raise the intellectual standard. For operating the steam plant, the high-speed stationary engineers and assistants were replaced by men trained on the Atlantic liners. They learned that a signal from the switchboard to start or stop an engine was as imperative as an order from the pilot house, and realized that, when required, engines must be kept running at all hazards. They were accustomed to the operation of engines with heavy parts, were self-dependent, and were found capable of acting promptly and with good judgment when the situation demanded it.

For the electrical operators the proposition was entirely different; the equipment being installed was of a new type, the de-

tails of which had not been fully developed, and consequently there were no men trained in its manipulation. Nor had any instruction books been printed, describing the construction of the apparatus, or its operation in connection with an electricity supply system, in a manner that would be comprehended by the men best fitted to operate it. Experience showed that the best men for this service were those who had some mechanical training and who possessed a technical knowledge of electrical apparatus about equivalent to the steam knowledge required for licensed engineers. These men submitted to the discipline and monotony of the position, became quickly acquainted with all the details of the system, and in case of trouble quickly ascertained the cause and then acted coolly and promptly. Their interest in the work is increased and the men are induced to study and improve their condition by promoting from time to time those capable of filling positions of increased responsibility, this being partially determined by periodical examination. As a rule, graduates from the technical schools have been found unsatisfactory for this class of work. As soon as they had mastered the details of the position the monotony of it would become irksome and they would secure employment elsewhere.

The method of instructing electrical operators varies with their positions, which in the New York Edison Company are graded as system operators, foremen, regulators, and various assistants. With the system operator, experience is the teacher, and the text-books are the load curves and reports from the entire system. These are made the subject of exhaustive study and from them are deduced plans of action for the future. In order to be prepared to meet exceptional emergencies, conditions are assumed and the operators in all stations are trained and drilled in executing a carefully prearranged plan. As an instance, twice each month the steam engineers at the generating station and the foremen and electrical operators in all stations are drilled under the direction of the system operator in starting engines and rotaries from rest, as would have to be done in case of total shut-down on the system. This drill, which consists in starting one and additional rotaries in the various substations, one and additional engines in the generating station, and synchronizing both rotaries and engines at low voltage and frequency, has brought out many details, such as methods of starting engines, low-voltage synchron-

izing devices, field excitation most suitable on generators and rotaries, the use of batteries, and so forth. By such means the men are trained to think and they also become familiar with what may be expected of them in case of serious disturbance.

A man is made a foreman only after he is thoroughly acquainted with all the known details of the construction, operation, and repair of the apparatus. His instruction, therefore, is on the broad lines of discipline, methods of handling and training men, thoroughness in investigation of trouble with apparatus or employees, and clearness, accuracy, and conciseness in making reports. He must maintain a certain dignity with the men, and guard against familiarity or favoritism. He should instruct the men to perform all operations and never personally operate a switch unless absolutely necessary.

For the regulators, assistant regulators, switchboardmen, brushmen, and so forth, it is customary to employ men for the lower grades and promote them to better positions when warranted. Each man is thoroughly trained and drilled by the foreman in the operation of the apparatus under his care and becomes perfectly familiar with all its connections before he is called upon to work on other apparatus.

As the apparatus in the stations increased and the connections became more complicated, various methods were developed in the different stations for accomplishing the same purpose. In order to avoid confusion and establish uniformity it was found desirable to issue rules and instructions for the electrical operators. In some cases it was found possible to make these rules inflexible, but in other cases broad and general instructions were issued as to the methods to pursue under given circumstances, and the man was depended on to use his judgment. The rules for all employees handling high-tension cables and apparatus, and detailed instruction for operating men as to the best methods to be followed in both generating and substation in case of serious disturbance to the system, have been issued in booklet form to the men, and their receipts taken, so that no excuse can be given for ignorance. Loose-leaf booklets are also available to all the operating men in the generating plant.

JOINT OPERATION OF POLE LINES

While there is increasing and proper pressure for the placing of circuits underground, a very large number of overhead lines must necessarily remain, and with the growing range of electrical services, the problem is often encountered of increasing the circuits without incurring public disapproval of the visible means by which supply is given. A significant example of the possible way of dealing with the question is furnished by the agreement made by the electrical companies of all kinds operating in Los Angeles to consolidate and combine their pole lines, with the result of abolishing more than half the poles in the city. Similar practice might, perhaps, not be allowed in other communities but it is at least suggestive of what can be done. A clearing house has been established for the consolidated companies and an extensive system of regulations and business by-laws has been drawn up, to which all of the companies must conform and enter into contract for, just as they would to formal articles of incorporation. The clearing house is maintained in a separate office, and ruled over by a committee made up of the managers of the different companies, that meets once a week for the transaction of business. The committee has a secretary, or secretaries, as one or more is found necessary, who works solely upon inter-corporation business, and to whom all orders, pole reports and plans for change are referred. There are three main agreements. The first is between the lighting companies and the street railways, the second between the two telephone companies, and the final between the parties of the first and the parties of the second part. The telephone companies go by themselves, and telephone wires are upon telephone poles alone. While light, power and railway cables are upon one side of the highway, the telephone systems rise upon the other, in combination, and thus the trolley wires find their usual suspension.

One of the articles of agreement is this: "In combination of the old lines, the companies will use the system having the highest poles." This settles definitely one point—as to whose poles should come down, and whose poles should stay up. All poles in the combination are to be neatly planed, uniformly painted and stepped according to the standard method.

Each party to the pact maintains his own corporate system of

wires, but the company on top—a coveted position—is to maintain the pole. A uniform price has been fixed, and will probably stand at 35 cents per foot, which all parties coming into the combination are to pay, and thus general expenses are to be shared.

In the matter of transmission lines, other than the regular lines, the agreement also contains a clause: "Each party owning a transmission line on top of the pole—the usual place for it—must own two shares of the pole's value." Thus, if a railroad and a lighting company are on the same pole, and the railroad has a feeder running along on top, the railway must own two-thirds of the pole's value. But if another electric company comes into the combination, the railroad will only have to own half the pole's value—still two shares of it. Details are not to hand as to the practical working of this system, but it seems to have decided merits.

RULES FOR WIRING

At the last meeting, in December, of the Underwriters' National Electric Association, some interesting modifications and recommendations were made in regard to the National Electrical Code. The committee on double and single-pole switches reported adversely to the suggestion that no single-pole switches be allowed and that double-pole switches be used in every instance. The committee on switches and cut-outs recommended one change, in connection with switches designed for use on Edison three-wire systems, which must hereafter be marked with both voltages, followed by the ampere rating, and the words "three-wire," as, for example, "125-250-volt, 30-ampere, three-wire." It was decided that the casings of all transformers in central or sub-stations must be permanently and effectively grounded through conductors having a carrying capacity not less than No. 4 B. & S. gauge, except in case of series transformers for instruments; a committee was appointed with power to provide rules relative to these latter instruments. Transformer secondaries of distribution systems may be grounded at the transformer or on the individual service, as provided in the Code. When transformers feed systems with a neutral wire, the neutral must also be grounded at least every 250 feet for overhead systems and every 500 feet for underground systems. Mr. Dow, of the Detroit Edison Company, cited cases in which this rule would be unfair, and a com-

mittee was appointed to consider this point. The ground wire in direct-current three-wire systems and alternating-current systems must hereafter never be less than No. 4 B. & S. gauge. Over specially inflammable stuff waterproof sockets must be used.

The rule providing that the insulation of transformers when heated shall withstand continuously for five minutes a difference of potential of 10,000 volts alternating between primary and secondary coils and between the primary coils and core, has been changed so that the time now is one minute, to agree with the rule of the American Institute of Electrical Engineers. The suggestion that the rule for switches, cut-outs and circuit-breakers should be modified so as to require no protective devices on the switch in the neutral or three-wire systems, and the resolution passed by the National Conference that "in case of three-wire systems with ground neutral a solid connection without fuse be permitted on the neutral wire," were referred to a special committee for action. The suggestion to amend the rules so as to allow the use of series incandescent lamps was referred to a committee that was instructed to report as soon as possible.

Hereafter under the head of "General Suggestions" as printed before the Code proper, will appear a suggestion urging upon architects the necessity for providing properly for signaling system wires in modern buildings, with suggestions also as to the proper methods of accomplishing this. The suggestion that a committee be appointed to consider special rules for the equipment of electric cranes was approved. No action was taken on the suggestion that outlet boxes be required at all outlets, and the recommendation that the grounding of secondaries be made mandatory passed also without any action, although the subject remains one of general agitation and discussion.

In this connection, reference may properly be made to the report last October of the committee on insurance of the Illinois Electrical Association, which stated that it found upon investigation that there had been no new schedules for central-station risks for ten years. The member companies responding to an inquiry on the subject paid in premiums in the past five years $124,105, and received in payment for fire losses $3911. Out of the 99 companies, members of the association, 45 of those that replied carried insurance and 30 did not. The committee, armed with these figures, went to the insurance authorities, with the

result that changes were in progress by which insurance on central stations could, where the buildings were of fairly modern construction, be reduced from 20 to 60 per cent. The committee estimated that the changes will save the members from $60,000 to $80,000 in premiums during the coming five years. The losses on the average risk in Illinois were stated to be 55 per cent of the amount paid in premiums, while on the central-station risks the proportion of losses to premiums was ridiculously small. Mr. Niesz, of the Chicago Edison Company, added that his company had sustained losses amounting to only two per cent of the amount paid in premiums, and part of that loss was through the spontaneous combustion of stored coal in the coal pile. The committee was continued to investigate the question of public liability and employer's insurance during the coming year. The National Electric Light Association has apparently no actual or active committee on any of these insurance questions, although a party to the enforcement of the National Electrical Code.

OLD AND NEW ILLUMINANTS

After working for years toward homogeneity in its lighting apparatus, the central-station art is now breaking away in a manner almost spectacular from its standard arc and incandescent lamps based on one member of the great electrical trinity—carbon, copper and coal. The carbon point and the carbon filament are challenged in every direction and are themselves taking on new structural and chemical conditions, so that they may well be in doubt as to their own identity. The day of the heterogeneous is upon us, and while the transitional process may be somewhat bewildering, the ultimate benefit to the art when the newcomers shall have determined their permanent value or absence of it, is obvious. It need not be wondered, therefore, that a new technical body has sprung into existence, the Illuminating Engineering Society, whose work promises to be of the most useful character in bringing the old illuminants up to a higher efficiency and in assisting to determine the value of the new sources of light. This young body has started out with a large membership recruited quite considerably from this association, as well as from the gas field, and its papers and discussions already give excellent promise. The illuminating engineer has an uphill task, but he has begun to prove that wasted light is wasted

money as well as wasted eyes and health; and that brings his mission home to everybody.

Treating more specifically the electrical part of illumination, as a public business, it may be pointed out that gas competition has in a way been responsible for the outburst of activity amongst inventors and central-station managers. Gas has thus paid back with interest the great stimulus it derived twenty-five years ago from the arc and the incandescent lamp. The adoption of mantles, seconding the improvement in gas production, made gas once more a strong competitor, while lately the gas arc and the "inverted" gas arc have pushed the electric even harder to the wall. In discussing gas arcs before the Pacific Gas Association, lately, Mr. W. M. Kapus asserted that with the gas arc, at the present time, a gas company has great possibility of increasing its output, and of obtaining a certain class of commercial patronage otherwise difficult to secure. Among the lighting companies the sale of the gas arc was advocated chiefly by those dealing exclusively in the sale of gas, while companies which operate combined gas and electric plants do not take so kindly to the gas arc. Gas companies that have followed a method of free installation and maintenance have met with much success in introducing the gas arcs. The cost of a regular four-burner arc complete with best grade of mantles is not over $7.50. This arc can be installed for the price of $12 and still leave a margin between the net cost and the net selling price to cover the expense of installation and a small profit besides. The gas company does not derive its benefit from this small profit, however, but from the increased sale of gas which can not be obtained unless gas appliances are within the reach of all. Even a reasonable loss on the sale of the appliance if encountered in order to create a greater demand for gas will appear as a very small percentage on the cost per 1000 cubic feet, on the annual output, as compared to the volume of new business that can and should be thus obtained. Mr. Kapus asserts that experience with 3000 arcs has shown that the total cost for maintenance averages about 25 cents per arc per month. Gas arcs constructed with a separate adjustment for each burner are far more satisfactory than those equipped with a single adjustment for two or more lights. When the arcs are used in exposed locations, the only precaution that is necessary is the proper adjustment of the pilot light, in order

that it shall not be extinguished when the lamp is not in use and allow unburned gas to escape. In discussion of the paper, Mr. Newbert remarked that it is important to consider the fact that where the fixtures are already in place single burners are cheaper to install than multiple burners, and that the greatest competitor to the electric lamp is the improved single burner. Mr. Colquhoun said that the gas arc is much more economical than single burners. The small burners consume about 5.5 to 6 cubic feet of gas per hour, while the four burners on a gas arc use about 21 cubic feet. There is, however, danger of breaking the mantles of a cluster when one is being replaced. A better distribution of light can be obtained from single burners than from arcs.

As offsetting this, at a meeting of the Electrical Section of the Western Society of Engineers, in Chicago, last October, Mr. H. Almert, who has the supervision of several central-station properties, stated that he had hit upon a good method of meeting the strong competition for store lighting put up by gas arcs with cheap gas. This applied to places where stores had formerly a few electric arc lamps on a flat rate, burning a certain number of hours every evening. In such cases Mr. Almert suggested to customers who were dissatisfied and were considering going over to gas arcs that several more electric arc lamps be placed in the store and that all be placed on a meter basis instead of a flat rate. In this way the customer was frequently able to obtain a very much more brilliantly lighted store without much or any increase in lighting bills and the threatened competition was kept out. The flat rates for arc lighting were, of course, based on burning a fixed number of hours each night, this number of hours answering the requirements of stores that close the latest. With the lamps on a meter basis, the customer could put them out as he pleased. Such a plan evidently increases the peak of the central-station load without much corresponding increase in revenue, but under the circumstances it appears that some such concession is necessary to meet competition.

The inverted gas arc is now being watched closely, though perhaps not anxiously, by the electric lighting fraternity, but it is evidently a field of work in which great improvement is needed or expected. Before a recent meeting of the Illuminating Engineering Society, Mr. V. A. Rettich presented a paper summing up defects as follows: (1) Dangers of falling par-

ticles. (2) Carbonization. (3) Flashing back. (4) Delicacy of mantle suspension. (5) Flickering light at low pressure. (6) Discoloration of chandelier arms. (7) In many cases a difficulty in attaching lamps so that they will be gas tight when set in the required direction. (8) Methods of gas regulation are too coarse. A much more delicate way is required. (9) Liability of breaking mantles when removing glassware. (10) Variations of diameters of globe rings, so that glassware is not interchangeable with different makes of burners. (11) Variations in means of fixing mantles to burners. (12) Too much heat thrown off in proportion to the amount of gas used.

USE OF THE NERNST LAMP

As one way of meeting the newer gas competition, the Nernst lamp is said to have been "making good" in a quite remarkable manner. It appears to be the general experience that one three-glower Nernst lamp taking 264 watts is able in commercial practice to replace the ordinary four-burner gas "arc" lamp; and this is confirmed by some recent tests which show that the useful light from a three-glower Nernst is about the same as that from a four-burner gas "arc." Assuming the Nernst lamp to be supplied with electrical energy at ten cents per kilowatt-hour, the cost of operating the three-glower, 264-watt Nernst lamp would be 2.6 cents per hour. Four-burner gas lamps, when burning at an efficiency making them comparable with three-glower Nernst lamps, consume in the neighborhood of 20 cubic feet of gas per hour, making a cost of 2.5 cents per lamp-hour, with gas at $1.25 per thousand cubic feet. With the cost to the user approximately the same, the electric light naturally has always the preference.

What can be done is best proved by one or two examples. The Yonkers (N. Y.) Electric Light and Power Company has a contract with the city to light the streets with 304 6.6-ampere alternating-current series enclosed-arc lamps and 522 25-cp series incandescent lamps. Most of the commercial lighting is by Nernst lamps and incandescent lamps, the total number of the latter connected being 42,220. The first Nernst lamp installed by the company was connected in January, 1903, and one of the most notable instances of its successful employment to win over the shopkeepers of a small city to the cause of electric lighting has been at Yonkers. Gas there sells at $1.00 per thousand cubic feet, but so successfully

has the electric light company pushed the Nernst lamp, that gas and gasolene arc lamps have almost entirely disappeared. Many shops, although still equipped with ordinary Welsbach mantle gas lamps and gas arc lamps, use the Nernst lamps in preference. The company supplies the Nernst lamp free of charge and looks after its maintenance, with the result that the business has grown enormously. On June 1, 1905, the number of Nernst lamps installed was as follows: 196 one-glower lamps; 382 three-glower lamps, and 13 six-glower lamps—a total of 591 lamps with 1420 glowers. The growth since then may be gauged from the number in use on March 1 of this year, which is as follows: 638 one-glower lamps, 571 three-glower lamps and 10 six-glower lamps—a total of 1219 lamps with 2411 glowers, making an increase of over 100 per cent in the number of lamps connected in nine months.

Or a Western town may be taken as a criterion. President M. T. Morrill, of the Golden (Colo.) Illuminating Company, sends the subjoined interesting data as to the adoption of the Nernst lamp there for street illumination: "Our old plant was the three-wire Edison system and we had in use on the streets eight enclosed multiple direct-current arc lamps, for which we received $8 per month each. In March of the present year we changed to the alternating-current system and installed alternating-current arc lamps in place of the direct-current lamps. The service was very unsatisfactory and by permission of the city council we substituted four-glower Nernst lamps for the alternating-current arcs at the same rental. We furnish the lamps and the maintenance as with the arcs. The lamps are mounted on the same brackets as were used for the arcs and are placed at each street intersection. The service has been very satisfactory and the cost of maintenance but little more than for arcs. There is a saving to us in current and attention that more than makes up this difference. In addition to the Nernst lamps, we have 75 incandescent lamps of 25 candle-power and we expect to substitute single-glower lamps for some of these on some of the more important corners."

Incidentally it is fitting at this point to refer to the great strides made in this type of lighting throughout the central-station industry. Up to January 1, 1906, the following plants had been equipped with the indicated number of glower units: Allegheny County Lighting Company, Pittsburg, 20,000; Edison Com-

panies of New York, 12,000; Columbus Service Corporation, 11,000; Milwaukee Railway and Lighting Company and Associated Companies, 7500; St. Louis Union Electric Light and Power Company, 6105; Maryland Telephone and Telegraph Company, Baltimore, 4500; People's Light, Heat and Power Company, Springfield, Ohio, 4500; Columbus Public Service Corporation, 4255; Hartford Electric Light Company, 400; Peninsular Electric Light Company, Detroit, 3700; Philadelphia Electric Company, 3000; Suburban Electric Light Company, Scranton, 3000; Paxtang Electric Company, Harrisburg, 2900; Fort Wayne and Wabash Valley Traction Company, 2703; San Antonio Gas and Electric Company, 2601; Minneapolis General Electric Company, 2500; Merchants' Light, Heat and Power Company, Canton, 2200; Salem Electric Light Company, Salem, 2171; Citizens' Electric Light and Power Company, Fort Worth, 2093; Cambridge Electric Light Company, Massachusetts, 1846; Portsmouth Street Railway and Light Company, 1555; Cedar Rapids and Iowa Railway Company, 1500; Public Service Corporation of New Jersey, 1500; Madison (Wis.) Gas and Electric Company, 1451; Canton (Ohio) Light, Heat and Power Company, Canton, 1440; Tioga (Penn.) Electric Light, Heat and Power Company, 1356; Worcester (Mass.) Electric Light Company, 1365; Wisconsin (La Crosse) Light and Power Company, 1131; Lansing (Mich.) Electric Light and Power Company, 1000; Bartlett Illuminating Company, Saginaw, 1000; Interborough Rapid Transit Company, New York, 1000; Youngstown (Ohio) Consolidated Gas and Electric Company, 1000; Potomac Electric Power Company, Washington, D. C., 1000. In addition over 200 lighting companies had glowers from 50 up to 1000 units—the unit being, say, three 16-cp equivalent.

PROGRESS OF THE LUMINOUS ARC

The first mention before this association of luminous arcs, produced by impregnated carbons, was made by your committee three years ago, when the Bremer type was described. Great advances have been made since then in the introduction of substances of high light-radiating power into the carbons; and at least a dozen "flaming" or luminous arcs are on the market and available for commercial purposes, while no small amount of work is being actually done. Including the magnetite lamp in

this group or type, it may be noted that one or two American cities have put in large numbers of these, Portland having several hundreds operated off mercury arc rectifiers with pronounced economy. Data as to Portland will be given in a separate paper. The "flaming" arc is conspicuous at this convention in the exhibits, and, as will be seen, is its own advertiser. It is no shrinking violet; those rays are absent. It is a good 2000-cp without any photometric circumlocution to explain how it could possibly be so rated. It is, as has well been said, "a bully light and a bullying light." It brooks no rival within several hundred yards; it sheds the rays of rising sunshine on every object, and it makes even the most glary incandescent sign pale its ineffectual fires. But since it can furnish at least five times the light per watt as the enclosed arc, it seems likely to give that successful illuminant "the time of its life" and may possibly come off winner; especially if it reforms and quits smoking. As to the extent to which impregnation of the carbons can be carried, Mehlke in Germany states that it has been found impossible in practice to increase the proportion of the additions with which the flame arc carbons are impregnated above six per cent, since above that limit the light is no longer steady; but he claims the possibility of increasing the impregnating additions with a resulting higher efficiency if the two carbons of direct-current flame arcs are impregnated with different materials. For the positive carbon, metals are suitable which form bases, like calcium, magnesium, barium, while the negative carbon should be impregnated with metals which form acids, like tungsten, chromium, molybdenum. Suitable additions for the positive carbon are fluorspar and magnesia and for the negative carbon tungstic acid and chromium fluoride. The diameter of such carbons may be increased so as to increase the life with the same length of carbons.

The only comparative figures known at present to your committee are, first, those of Mr. Pearce, of the Manchester (England) station, who gave, last October, data as to the cost of gas and electricity and the relative amount of light obtained in commercial use in a street in Gorton. His figures show that with electric light 75 per cent more illumination was obtained for an 18-per cent increase in price, compared with incandescent gas lighting. He gave some figures for lighting Fleet street by flame arcs either by short-hour lamps (16 hours) or by long-hour lamps

(45 hours), and concluded with the following comparative figures showing the selling costs of different systems of illumination for 1000 effective candle-power-hours per year with electricity at three cents per kilowatt-hour:

Flame arcs (long hour)	1.075
Flame arcs (short-hour)	1.35
Ordinary carbons, single enclosure, long-hour (Manchester)	1.6
Fleet street (incandescent gas)	2.4

No doubt other figures are obtainable in this country, but are not yet public. Mr. E. L. Elliott in a recent paper before the Illuminating Engineering Society gave the subjoined report of measurements by the Electrical Testing Laboratories with "yellow" and enclosed arcs:

	Luminous Arc	Enclosed Arc
Mean amperes	8.	5.1
Mean volts at arc	45.	81.
Mean watts at arc	360.	413.
Mean spherical candle-power	1020.	232.
Mean lower hemispherical candle-power	1560.	260.
Watts per mean spherical candle-power	0.353	1.78
Watts per mean hemispherical candle-power	0.265	1.59

Dr. Hoppe also made a report in Germany recently with special reference to series working. He noted the fact that there are a great many different factors besides power consumption that must be taken into account in determining the economy of a given type of lamp, and gave a number of tables and diagrams comparing the economy of the different lamps with respect to power consumption alone. In order to get 2000 hefner candles there are consumed (1) with ordinary carbons:

110	volts,	2	lamps	in series,	1250	watts
"	"	3	"	"	1060	"
220	"	4	"	"	1575	"
"	"	5	"	"	1350	"
"	"	6	"	"	1350	"

(2) with flame arc lamps:

110	volts,	2	lamps	in series,	800	watts
220	"	4	"	"	950	"
"	"	5	"	"	1000	"

For those who have not yet gone into the subject, it may be added that luminous arcs are run on either direct or alternating circuits; when the latter, at 60 cycles and upwards. They take about 45 volts at the arc and are therefore run two in series on 110-volt circuits, and so on upwards.

Some other general figures comparative of illuminants were given recently as to cost of lighting for streets in Croydon, England. The figures below express the average cost in cents per candle-power-year and will be seen to include alternating flame arcs:

	Cents
Electric arcs, direct connected, 520 watts, alabaster globes	17.40
" " alternating current, 650 watts, half opal globes	17.92
" " " " 450 " " " "	29.18
" " " " 500 " " " "	31.88
" " direct current, 690 watts, alabaster globes	17.40
Nernst lamps, 0.5 — ampere	29.32
Incandescent gas lamps	24.90
Croydon Gas Company	31.58
South Suburban Gas Company	31.64
Alternating-current flame arc, 550 wàtts, opalescent globe	6.15
Santoni lamp, 430 watts	7.34
Incandescent lamp, with Reason fittings	24.63

The Croydon committee reporting said that gas had been considerably improved by means of high-pressure lamps, but although these advances have been made, so long as the price of electric arc lamps does not exceed a certain amount, the cost of lighting by means of the ordinary direct-current arc lamps should be more economical than by the high-pressure gas lamps. The committee also found that considerable improvements have been made with electric arc lighting, brought about by the introduction of the "flame arc lamp."

SMALL CARBONS AND SMALL ARC LAMPS

There is perhaps not much to be said with regard to standard arc lamp practice, but it is worth while to mention the use of smaller carbons by the Chicago Edison Company. It is claimed that there is a marked increase in the amount of light obtained from a given quantity of power as well as a whiter light. The lights are also steadier, as the arc can not wander so easily around the crater. The size of carbon ,adapted is five-sixteenths inch. On a 3.5-ampere lamp the use of five-sixteenths-inch carbons as compared to the usual half-inch carbons, gives a consumption of 2.2 watts per candle, as against 3.4 watts with the one-half-inch carbons, or an increase of 50 per cent in light. It is necessary to change the lamps slightly to use the smaller carbons and this is done in the company's repair department. The gain in steadiness and efficiency is found to be of much importance, especially in meeting the competition of gas-arc lamps. The com-

pany is now obtaining a life of about 100 hours from the five-sixteenths-inch carbons. The smaller carbons do not blacken the inner globes as much as the larger carbons. With large carbons it was necessary in order to secure good efficiency to clean the inner globes every 70 hours, or once between each trimming. It is now unnecessary to clean between trimmings. The increase of efficiency by the use of smaller carbons, as well as the greater steadiness and improved color of the light, due to the fact that there is not such a preponderance of violet rays, are matters upon which laboratory tests are hardly necessary, as they are apparent even to the casual observer. Before five-sixteenths-inch carbons were made the company's standard, the matter was exhaustively tested by Mr. G. N. Eastman. Some alternating-current arc lamps have also been equipped and put in service with five-sixteenths-inch carbons with great improvements in the illumination.

Small arc lamps are relatively unknown in this country, though not for want of experiment. Lamps of this type have been introduced this year in Germany by the Siemens-Schuckert Company to close the gap between the standard arc and the ordinary incandescent. On account of the liliputian dimensions, economical burning and simplicity of handling, they can be employed equally well for indoor as for outdoor purposes. They are built for either direct or alternating-current circuits. The direct-current lamp has a restricted supply of air and is generally built for a single globe. For the regulation of the carbons it contains a movable clamping arrangement. The lamps are constructed for a consumption of about two or three amperes, at about 80 volts. The two-ampere lamp with an alabaster globe gives a hemispherical light of about 130 candle-power at a consumption of 1.2 watts per candle, while the three-ampere lamp gives 280 candle-power at .85 watts per candle. The special cored carbons of these lamps are about one-fifth of an inch in diameter, the length of the upper carbon being about 7.5 inches and of the lower 2.5 inches; when the upper carbon has burned down to 2.5 inches, it can be used to replace the lower. The outer dimensions of the "Liliput" are very small; the cylindrical cover has a diameter of 2.5 inches and measures 12.3 inches in length, while the globe has a diameter of 3.25 inches. In another type of this lamp 100-volt direct-current can be used, or two of them may be connected in series on 200 or 220 volts. Each lamp operates at

an active pressure of 80 volts, and according to its design consumes 3.4 or 5 amperes, giving an average hemispherical illumination of 355, 500 or 760 candle-power, respectively. The upper carbon is 10.5 inches long, while the lower is 3.5 inches. The two carbons burn in an almost airtight space for about 25 hours at one trimming. The carbon consumption is stated to be about one-twentieth of that found with open arcs. The mechanism is extremely simple and contains only a grip feeder. It permits the lamp to assume normal condition rapidly after the circuit is completed without undue hunting. It is expected that these lamps will prove successful competitors against the gas-arc lamps, and they have already been imported, so that American central-station companies can try them if they wish.

A novelty in arc lighting is the Vogel lamp shown recently at Liege, Belgium, consisting essentially in a combination of the carbon arc and mercury-arc types, just as the combination has already been tried of the mercury arc and the incandescent, to supply the missing red rays. In this hybrid lamp the lower vertical carbon is placed in mercury amalgam, and the arc has a notable bow form. It is said that according to the nature of the amalgam, white or colored light can be obtained. The lamp at Liege had triple carbon sets, with a common feed regulation; the carbons were credited with a life of 1600 hours, and it is said that the lamp gave "considerable quantities of light," which is at least probable.

VAPOR LAMPS

Considerable progress has been made during the year with mercury and other "vapor arcs" of the tube type, and the unquestionable economy of these lamps gives them an enlarging place in the field of electrical illumination. Such lamps are now to be seen everywhere, and familiarity has bred greater complacency as to the color values of some of them. Mr. D. McFarlan Moore, so long a worker in this branch, has of late given his energies specially to the continuous tube method and has installed several commercial plants of that type. One notable installation was that with a single continuous tube all around the lobby of Madison Square Garden during the recent electrical exhibition there. The tube was no less than 162 feet in length.

The Cooper Hewitt mercury vapor lamps are now in univer-

sal evidence, and some have been so long installed that data are obtainable as to endurance. The New York Transportation Company has recently renewed four tubes in its automobile garage, each having an operating record of over 10,000 hours, and frequent instances are cited of 3000 hours. This with a consumption of from 0.55 to 0.64 watt per candle puts such a light well in the lead, on some accounts; while the fact that the lamp has now been successfully adapted to alternating as well as to direct-current circuits insures greater vogue and popularity. Note was made by your committee last year of the effective service given by these tubes in the printing plant of the New York *Times;* and other striking examples may be cited. In the New York post office 53 such lamps are in use, while in the Washington, D. C., post office 30 requiring 105 amperes are in use in the large mailing room 100 by 200 feet, replacing 1000 incandescent lamps at 500 amperes. The Mott Iron Works, at Trenton, N. J., have been equipped with 113, and the Newark, N. J., Westinghouse shops with 470. It may be added that the new alternating-current type consumes 275 watts on 110 or 220-volt circuits or 0.64 watt per candle-power.

INCANDESCENT LAMPS

Improvement and research have been very active in the department of incandescent lighting, with marked benefit to the station and consumer, though not at present to the manufacturer, who finds himself going through a transitional period of intense activity and can neither lag behind in the quest for novelty nor determine new standards for permanent staples. The tantalum metal filament lamp, the subject of so much interest, is not yet on the market in America, although it is understood that negotiations have been concluded for its manufacture here. Meantime, a large amount of testing has been done, and these figures go to confirm those already favorable to the low wattage per candle-power. The figures are given below of one series of measurements, by a well-known laboratory, on ten tantalum lamps from Germany:

CANDLE-HOUR PERFORMANCE OF TANTALUM LAMPS

Lamp No.	Initial Cp	Watts per cp	Broken at Hours			Total Life in Hours
1	24.7	1.94	88			
2	23.5	1.97	890	1007	1013	1013
3	21.0	2.17	760			760
4	22.1	2.06	700			700
5	23.8	1.99	813			813
6	24.0	2.00	706			706
7	26.1	1.86	712			712
8	25.4	1.81	484	572		572
9	23.2	2.03	596	625		625
10	25.0	1.90	710	939	968	968
Average	23.8	1.98				763

Lamp No. 1 was accidentally broken at the end of 88 hours and is, therefore, not included in the average. With lamps No. 2, 8, 9 and 10, when rupture first occurred in the filament it was possible to re-establish the circuit by tapping the lamp, which caused the loosened end of the filament to make contact with an adjacent section, short-circuiting part of the filament. This caused a decrease in resistance and a corresponding increase in mean horizontal candle-power. With lamps Nos. 8 and 9 the filament could be repaired in this way after the first rupture only, with lamps 2 and 10 after the first and second ruptures. The last column in the above table gives the total life whereby the life of the lamp is not considered exhausted until the filament is in such condition that the circuit can not be re-established. In making the tests, on direct current, the lamps were rotated at 40 to 50 r.p.m. Automatic voltage regulation was used, supplemented by hand control, and the average variation of pressure did not exceed one-half per cent.

At the last meeting of the Ohio Electric Light Association, Professor W. Ambler presented a valuable paper on some tantalum lamp tests. Two lamps were tested, one with the clear and the other with the frosted bulb. The consumption of the former was 1.75 and of the latter 2.0 watts per mean horizontal candle-power. On the basis of mean spherical candle-power the consumption was 2.23 watts and 2.67 watts per candle-power, respectively, the corresponding figures for a clear-globe carbon-filament lamp being 3.72 watts. The clear tantalum lamp was thus found to take 57 per cent and the frosted lamp 64.5 per cent as many watts per horizontal candle-power as the carbon lamp, which latter had a consumption of 3.1 watts per horizontal candle-

power; the tantalum with a clear bulb took 60 per cent, and the frosted lamp 72 per cent, as many watts as the carbon lamp on the basis of spherical candle-power. As compared with the carbon filament, it was found that it requires practically twice the change of voltage across the tantalum lamp to cause the same change in light. During a life of 1000 hours both the tantalum lamp and the carbon lamp fell off 28 per cent in candle-power, while the increased consumption of current in the case of the tantalum lamp was 37 per cent and in the case of the carbon lamp 33 per cent. These figures show that the energy taken by both the tantalum and the carbon lamp is practically constant during the life of the lamp. In Germany the cost of the tantalum lamp is 80 cents in barrel lots, as compared with about 16 cents for the carbon lamp. With these prices a calculation is given by Professor Ambler showing that there will be a saving by the use of the tantalum lamp only when the cost of energy is above 5 cents per kilowatt-hour. This, however, does not include the value of burned-out lamps; allowing 50 per cent of the original cost as the value of a burned-out lamp, there will be a saving of 35 per cent in favor of the tantalum lamp with energy at 10 cents per kilowatt-hour; with energy at 5 cents per kilowatt-hour the saving amounts to 31.5 per cent, and at 3 cents to 13.5 per cent.

As to the status of the lamp abroad, it is stated by the makers, the Siemenses, that for the present the use of the lamp should still be restricted to direct-current circuits, the life being shortened and the globe showing a tendency to blacken on alternating. "We have had many inquiries" they say, "as to why we do not put the 110-volt lamp on the market with a candle-power somewhere about 15, the general opinion being that 23 candles is too high for most requirements, although the current consumed is actually less than for the 16-cp carbon filament lamp. According to present manufacturing arrangements, in order to reduce the candle-power it is necessary to have a lower voltage lamp, so as to secure the same high efficiency. We are now prepared to accept orders for 2.2-watt lamps for pressures of 50, 55, 60, 65, 73-75, 100 and 110 volts. These lamps have a useful life of about double that of the lamp described above, and give 30 to 40 per cent less light, with a consumption at starting of 2.2 to 2.4 watts per candle-power. For instance, the 110-volt lamp of this type gives a light of about 14.5 candle-power with a consumption of 2.2 watts per candle-

power. Its useful life is about 800 to 1000 hours, and the total life often reaches 1500 to 2000 hours. With the consumption mentioned, a lamp having such a long useful life is a great improvement on anything that has been produced in connection with carbon-filament lamps."

The osmium lamp may still be regarded as a newcomer in the incandescent field, although referred to in earlier reports of your committee. The lamps are now made in Germany and England and some have been imported, of the standard type 50-volt, 25-cp, guaranteed at 1.5 watts per candle. The filament, which has an approximate length of 15 inches, is divided into three separate loops connected in series by means of two loops of platinum wire, the middle of each of which is fused by means of a glass head to the top of the stem carrying the two leading-in wires. Each filament is anchored in order to prevent the loops from touching the dome of the bulb. The anchoring device consists of a small glass rod, to the end of which is attached a turn of small wire or white refractory material. Formerly these anchor terminals were made of metal, but as it was found that the filament always parted at this point the refractory material was substituted. The filament is anchored, not at its extremity but somewhat above the turn of the loop. The lamps can be burned only in a vertical position.

Another lamp of this class is the small one of which the filament is made from an alloy—zirconium being one component. The lamps require only a small e.m.f., such as two or four volts, so that only one or two storage cells are necessary. Some data are given by Mr. J. Laffargue of Paris on a 2-cp lamp which at four volts consumed 0.46 ampere (this gives a specific power consumption of 0.92 watt per candle-power). This is compared with an ordinary incandescent lamp of 2 candle-power, which at 8 volts consumes 0.95 ampere, corresponding to a power consumption of 3.8 watts per candle-power. While this new lamp is more expensive in first cost, the cost of operation is much less on account of the higher efficiency. Another zirconium lamp not yet on the market, but brought to notice in Europe by Gaster, is said to have a consumption of 1.2 watts per candle with a life of 500 hours, but needs careful handling and is possible only on low voltages.

The latest competitor to arrive on the scene, in the metallic

filament group, is the Kusel, for which some interesting results are claimed. Dr. H. Kuzel, of Baden, near Vienna, has developed a process applying to refractory metals, "such as platinum, chromium, manganese, molybdenum, uranium, tungsten, vanadium, tantalum, niobium, *et cætera.*" The method of manufacture is as follows: The metal is reduced to a colloidal state by a process such as that of Bredig in which an electric arc is produced under water between a pair of rough electrodes of the metal in question. Dr. Kuzel recovers this finely divided metal and forms filaments by forcing it through a die. The metals are dried at a temperature of 60 to 80 degrees centigrade for 5 or 10 minutes, when they become conductive, but they lose their conductivity again on cooling. To restore the conductivity they are placed in vessels which have either been evacuated or contain only inert gases such as hydrogen, and are first heated to 60 or 80 degrees centigrade to render them conductive and then raised to white heat by an electric current. This, it is stated, restores them to a crystalline state and at the same time diminishes their diameter as well as their specific resistance, and the filaments are then ready for use.

The lamps are exactly similar in appearance to the carbon-filament type with the same size of bulbs. Two horseshoe filaments in series are used and the lamps can be made up to 110 volts. It is hoped, however, to extend the limit up to 220 volts. The mounting of the filament and exhausting of the bulb is precisely the same as for the carbon lamp. The efficiency claimed for the filaments for low-voltage lamps is indicated in the tests published, and it should be explained that the candle-powers given are mean horizontal, the hefner unit being used. It has been found from a number of tests that a useful life of about 3500 hours may be expected, with a loss of candle-power varying from 2 per cent to about 11 per cent for lamps with a consumption in the neighborhood of 1 watt per candle, and that they will last as long as 5000 hours with a diminution in light of 20 per cent. Lamps working at a consumption of about 0.75 watt per candle have been run for 1000 to 1100 hours with a loss of 3.5 per cent, and for 1600 hours with a loss of 20 per cent. The lamps remain remarkably cool in use as a very small portion of the radiation consists of infra-red rays. The lamps are equally suitable for alternating and continuous-current circuits, and can be

overrun as much as 300 per cent without damage. The inventor looks forward to producing lamps with a consumption as low as 0.5 watt per candle.

As to this new lamp, Mr. J. Kremenezky gave the subjoined data of tests a month or two ago before the Vienna Electrical Society. More than 100 lamps have been tested, partly in the factory and partly in a testing laboratory. The first tests in the factory showed an average power consumption of one watt per hefner candle (.88 ordinary candle) with a useful life of at least one thousand hours, the average decrease of candle-power being not more than 15 per cent of the original value. The author points out that these results were obtained with a testing current not furnished from a storage battery, but from the ordinary supply mains. The results, therefore, represent what may be expected from the new lamp in actual practice, where the lamps are subjected to variations of voltage.

Later tests have shown steadily improving results, some of which are quite remarkable. The following table refers to a 19-volt lamp:

Hours	Hefners	Amp.	Watts per Cp	Difference in Cp. in %
0	29.0	1.48	0.97	0
503	28.8	1.48	1.02	— 0.7
1110	26.2	1.49	1.08	— 9.7
1686	25.2	1.48	1.11	—13.1

After 1686 hours the voltage was raised in order to see how much increase of voltage the lamp would stand. At 60 volts the filament was disrupted, but spontaneously "soldered itself" and the lamp continued to burn. The behavior of a lamp with increased voltage is shown in the following test of a normal 20.2-volt, 19.5-cp 0.97-ampere lamp consuming one watt per candle-power.

Volts	Hefners	Amperes	Watts per Cp
20.2	19.5	0.97	1.00
25.8	50.0	1.14	0.588
32.7	100.00	1.30	0.425
34.5	125.00	1.34	0.370
39.0	180.00	1.44	0.312
40.6	211.00	1.475	0.283

Coming back to more standard forms, it may be noted that just after the Denver convention of this body last year, Mr. J. W. Howell presented before the American Institute of Electrical Engineers, at Asheville, a new type of "metallized carbon" fila-

ment lamp. In the interim the lamp has become generally known to the members of this association; but it is appropriate to note its appearance briefly in this report. This lamp is rated at 2.5 watts per candle-power. Several forms of holophane reflectors are used with this lamp. It is stated that the new filament is obtained by applying an additional process to the present carbon filament treatments, which includes heating in an electric furnace to a temperature of 3000 to 3700 degrees centigrade, this firing being performed both before and after treating. This results in producing an exceedingly pure form of carbon, having considerably less specific resistance and greater density than the older filament. The process also changes the temperature coefficient from negative to positive. For this latter reason the term "metalized" has been employed to describe the new filament, although it contains no metal. Thus far the lamp has been available in three sizes, requiring 125, 187.5 and 250 watts per lamp, the smallest being rated at 50 candle-power.

Aside from all these improvements, economies and higher efficiencies, the fact remains, as shown during the year by numerous articles and discussions, that much can be done with existing lamps to better their service by keeping them free of dust, by employing the right shades and reflectors and by studying their skillful disposition in a room. All such literature is in the highest degree valuable to a central-station manager. Nor should the useful little "turn-down" lamp be overlooked. As was said recently by Mr. W. J. Phelps: "The uses of a turn-down lamp have from year to year enlarged in their importance. Where formerly it was supposed to be of benefit only in the nursery and sick room, it has come to be quite frequently adopted for every room in the house. Such use is based on common sense. It seems reasonable that the supply of any commodity should be regulated. If we were obliged to use water faucets in which the water must be turned on full or off entirely, it would be very inconvenient, even if the water cost nothing. If coffee were to be sold only in ten-pound packages, there is little doubt but that it would work great inconvenience, and probably reduce the consumption of coffee. While the average man usually installs a turn-down lamp as the result of some particularly large lighting bill, and for the purpose of cutting down expenses, he is quite likely to discover that he has secured a considerable addition to

his personal comfort, and personal comfort, in spite of all our improvements and inventions, is still a most important item to be considered."

RATES AND METERS

The year has witnessed a quite general reduction in prices for current and service all over the country, and an extension of metered service, limiting still further the use of the old barbaric "flat rate," unmetered system. The production of meters has grown apace. But there is to-day no greater agreement on methods of charging than before; and the present meeting will doubtless do its share in bringing out the merits of and arguments for, the various "maximum demand," "two-rate," "readiness-to-serve" and other tariffs or rate principles. Meantime a great many companies have addressed themselves to the problem of building up the load at certain times and seasons. Some years ago an innovation of radical character was made at Montreal, Canada, by Mr. P. G. Gossler, in inducing numerous large factory consumers of electrical energy, in consideration of specially low but not at all unprofitable rates, to shut down early in the winter afternoon before the domestic and office lighting load came on. This has involved social and even psychological changes, but has obvious advantages, and is now being worked successfully by a large station on Long Island. At Rockford, Ill., there has been an extraordinary development of the automobile charging load. The company makes a rate of 6 cents per kilowatt-hour for automobile charging, the contract providing that no charging shall be done between the hours of 5 and 8.30 in the evening in winter, and no difficulty has been experienced in obtaining compliance with this clause of the contract. At one time, the company was troubled with low voltage in the residence district where most of the automobiles are located. A letter was addressed to the automobile customers, stating that the company had received some complaints of lights being dim and that it had reason to believe that these complaints were due to the fact that some customers were charging automobiles during the evening although the low rate given for automobiles was in consideration of the observance of the rule not to charge between 5 and 8.30 p. m. The trouble stopped immediately. Some customers even went so far as to apologize and explain that they did not

remember there was such a clause in the contract. It may be added that the Rockford Company also looks after the 60 autos on its circuits free of charge as to the electrical apparatus. The company is well satisfied with results, and is an exemplar to others of practical work in benefiting itself while helping to build up a new industry that deserves the support of the older branches.

Note has been made before of the low rate contracts made at Red Oak, Iowa, for the operation of refrigerating machine motors, which the central-station company has the option of cutting off during its peak-load hours if it desires. Most of the central-station companies with contracts for city water pumping have taken these at a figure much lower than they could afford if it were not that they have control of the hours of pumping, so that they do not come on during the lighting peak. One enterprising central-station company, in a town of 20,000 inhabitants, is operating a very economical electric and hot-water plant, which maintains a load factor on week days of 55 per cent for 24 hours. The economy of production in this case is in no small degree due to the high load factor maintained through a large number of factories taking power under contracts which expressly stipulate that at the company's request power shall not be used during certain hours, these hours being closely calculated so that the factory power users shall not come on at the top of the winter peak, and at the same time shall not be seriously inconvenienced by being obliged to shut down during these hours.

While upon this subject, it may be noted as of decided interest that in England where the Wright maximum demand system has been such an educational factor, rates have lately become much more heterogeneous. Brighton, the town in which the maximum demand system was born, has hitherto been among those in which every consumer was charged on that system, but the Brighton municipality has now decided to give every consumer the option of being charged at a flat rate of 8 cents instead of on the Wright system at 14 cents for the first hour and 2 cents after. As it requires a two-hours' use of the maximum demand per day at 14 cents and 2 cents to bring the average charge down to 8 cents per unit, it is said to be probable that a large number of consumers will adopt the alternative. The contrary conditions appear to prevail in the United States where the productive capacity of

meters of this class is now 1000 per week, and where the output is, so far as reported, 34 per cent ahead of that of last year.

PROTECTION AGAINST ACCIDENT SWINDLES

In a recent address before the National Municipal League, one of the chief officials of the Detroit municipal electric light plant asserted that "legal expenses" for public service corporations meant nothing but a cover for bribery and corruption. If this outrageous charge were true, the average manager would perhaps worry little about the burden this imposed on him, but it happens that no small part of the item is due to fighting fraudulent attempts to collect claims for bogus accidents; and the evil has reached such a point, that concerted action is now being taken against it. Last November an organization to be called The Alliance Against Accident Frauds was formed in New York city. There were present at the meeting representatives of corporations from Boston to Chicago, and letters were received from many others saying that they would join the alliance. The objects of the alliance are: To protect and defend its members against fraudulent claims and prosecute all persons engaged in presenting or promoting such claims; to collect and disseminate information to its members concerning fake claimants, shyster lawyers and unprincipled physicians, ambulance chasers, false witnesses, and others engaged in such practices and methods; to insist upon fair dealing with honest claimants and generally to impress upon the public the principles for which the alliance stands. The companies represented were the United States Casualty Company, General Accident Corporation, Philadelphia Casualty Company, Great Eastern Casualty Company, New York City Street Railway Company, United Railways and Electric Company of Baltimore, Chicago and Northwestern Railway, New York Central and Hudson River Railway, Boston Elevated Railway, Washington (D. C.) Railways and Electric Company, Delaware, Lackawanna & Western, Hudson River Day Line, Travelers' Insurance Company of Hartford, Philadelphia Rapid Transit Company, Interborough Railway Company, Casualty Company of America, Little & Company and the Fuller Construction Company. In the discussion of the plan and scope of the new alliance it was said that its mere existence would frighten off many persons who otherwise might bring fraudulent suits. It will be part of the

plan to inform stockholders and policy-holders in every corporation in the alliance of every case that is to be fought and the reason for contesting it. By this wide publicity it is thought that fraud will be made additionally difficult and dangerous. It was said at the meeting that the alliance will do quite as much work to see that honest demands are promptly settled as it will to detect swindlers. With fraudulent demands out of the way, it was said, the railways and accident companies could give more time to genuine cases and settle them more promptly.

An effort is also to be made to have passed in every state laws similar to those passed by the Maryland legislature against so-called ambulance chasers and dishonest physicians. At the meeting of the American Bar Association at Narragansett last summer the question of barratry was taken up, and that organization said it would co-operate with any association that would labor to put down the practice. A committee was appointed to confer further with the American Bar Association and with the American Medical Association on the subject. This work seems well worthy of the co-operation of the National Electric Light Association.

STATE LIGHTING COMMISSIONS

A difference of opinion has been shown to exist on the subject of the desirability of State Lighting Commissions, but it is evident that they will become more numerous; so that their formation and action demands watching by this association. The New York Commission has entered upon its career during the past year and has already made its report and heard a number of appeals within its jurisdiction as to rates, capitalization, competitive companies, and so forth. At the meeting last November of the Empire State Gas and Electric Association, there was a very interesting discussion as to competition, fair and unfair, and the necessity that companies in the field which had been put under the aegis of the State Commission, should be able to look to it for relief. One of the members called attention to the fact that although his company was doing good service to the community at low rates, within the past year no fewer than four new franchises had been granted for operation in the same field. It was obvious that if all these companies were allowed to go into business there must be a period of reckless competition, at the end of which invested capital must again assert itself and the community would

suffer, to say nothing of the serious economic waste involved generally.

STANDARDIZING ELECTRICAL MACHINERY

This association has already done much to standardize apparatus, nomenclature and ratings, joining with the American Institute of Electrical Engineers and other bodies in useful legislation of this character. Your committee deems it proper to call attention, therefore, to the fact that in pursuance of the resolution of the Chamber of Delegates of the International Electrical Congress at St. Louis, in 1904, to the effect that an international commission from the technical societies of the world should take up the standardization of the nomenclature and ratings of electric machinery, it is proposed that a meeting of delegates from the various national electrical engineering societies shall be held in London on the 26th of June next. The rules proposed for discussion at the meeting have already been drafted and printed. These rules relate entirely to the organization of the commission and do not touch upon the electrotechnical subjects to be considered. The proposed rules are fourteen in number, prepared with the hope and intention of facilitating action. The main object at present to be sought is a meeting of delegates from various national electrical engineering societies to deal with this important question.

THE PRESIDENT: We have been fortunate enough to find one gentleman who has had very wide experience in the use of magnetite arc lamps and mercury rectifiers. I am glad to welcome him to-day—Mr. W. S. Barstow, of Portland, Ore., who will now read his paper on *Mercury Arc Rectifier System with Magnetite Lamps for Street Illumination.*

Mr. Barstow presented the following paper:

MERCURY ARC RECTIFIER SYSTEM WITH MAGNETITE LAMPS FOR STREET ILLUMINATION

Many times in the history of the electrical industry the end of a particular commercial development appears to be near at hand, only to be indefinitely postponed by a new discovery in this or some other allied science which accidentally opens up new possibilities. Often, again, the failure in some special line is caused by the absence of a single element which, when forthcoming, turns the failure into an important success. Sometimes all the elements are present, but scattered through different industries, so that there is not a sufficient familiarity or knowledge in the hands of any one person or group of persons for a combination to produce the desired result.

Among all the radical changes in the details of the industry during past years the electric arc lamp has shown but little material progress. It is true that there have been evolved the high-tension, the low-tension, the open, the enclosed, the direct and the alternating-current systems, with their many modifications, but in none of these has there been any departure made from the carbon arc and its relatively uniform efficiency for a given illumination. From the day of Sir Humphrey Davy, in 1808, when with a battery of 2000 elements he produced his four-inch flame between charcoal points, to the present refinement of the 150-hour enclosed lamp, progress has been confined more or less to mechanical improvements. The commercial arc lamp of the early day was of open-arc type, requiring 500 watts at the arc to produce what was then termed a "nominal" 2000-cp light or a certain illumination. After passing through the series and multiple stages, the enclosed lamp was evolved, economical in maintenance, but with no improvement in consumption of energy. This in the direct and alternating-current form is the type in general use to-day.

There has during the last two years been in course of development a new system (if it may be so called) for outdoor street arc lighting, which not only promises to take an impor-

tant place in the history of the art, but in many instances to replace the carbon arc. It is actually the first successful effort to increase commercially the efficiency of outdoor arc illumination, while at the same time it opens up new fields where the present type lamps can not be used. The magnetite mercury arc rectifier system requires not only 35 per cent less energy at the lamp than any existing system for the same illumination, but makes it possible to do outdoor street arc lighting from transmission systems of 35 cycles and under without the use of motor-generator sets or other moving apparatus. In the city of Portland, Ore., about two years ago this system was installed on a small experimental scale. The street-lighting system at that time had been in successful operation for many years and was of the old-style open-arc type, supplied with direct current.

In the very early days current supplied to Portland was generated by water-power at Oregon City, about seventeen miles south of Portland, and was transmitted to Portland for arc and incandescent lighting. As all arc lighting was done on the high-tension system and incandescent lighting on the high-frequency, single-phase system, each machine had a separate set of feeders from Oregon City to Portland. (This was one of the first instances where, previous to 1892, single-phase, high-frequency machines were operated at a direct pressure of over 4000 volts.) The business increased so rapidly that in 1891 there was transmitted in actual commercial capacity energy for 7200 incandescent and 650 arc lamps by means of the systems above mentioned. As business grew and electric railways were installed in Portland, a second power plant was built at Oregon City, and a 33-cycle, 3-phase, 5000-volt system installed, with direct-connected vertical wheels, especially arranged for a head varying from 15 to 45 feet, and current was transmitted from there by rearranging the original arc and incandescent circuits, each generator being connected to a single three-conductor, three-phase feeder. To each feeder in Portland were connected a set of statics and a rotary transformer, so that there were practically a number of independent generating and transforming plants. To provide for the city lighting motor-generator sets were installed in Portland, each set consisting of a direct-current T.-H. motor directly connected to two direct-current arc machines. Thus, in these early days several transformations were necessary before the alter-

nating current delivered to the substation was finally distributed to the system, and it required 806 watts per lamp of the transmitted energy in the form of 33 cycles, 5000 volts, three-phase, to supply each 500-watt lamp installed in the city. In remodeling the system, as no arc lighting could be taken from the transmission frequency of 33 cycles, it was either a case of using alternating-current, high-tension motor-generator sets, changing the frequency from 33 to 60 cycles, or a high-tension motor directly connected to direct-current arc machines. Under these conditions, and with the original idea of reducing motor-generator capacity and the investment in generating system, several magnetite lamps were installed as an experiment about two years and a half ago, and from that time to the present modifications and improvements were made until now the lamps are equal in all respects to any arc lamp of either alternating or direct-current system. In the meantime lengthy experiments were made with the mercury arc rectifier. About one year ago the results appeared so promising and so much progress had been made in such a short period that an order was placed to install the entire system of over 1200 lamps in Portland with mercury arc rectifiers and magnetite lamps. There have now been in operation in Portland for several months over 800 lamps with rectifiers, and the installation is being rapidly increased as fast as deliveries can be made. The system has proved successful and has fulfilled expectations. Considerable difficulty in the form of static discharges and short life was at first experienced with the tubes. The tubes, which were of small size, were subjected to very rigid requirements on account of the alternating-current pressure of 22,000 volts (open circuit), a pressure which was very much higher than anything yet attempted with mercury arc rectifiers. The tubes have now averaged over 650 hours and several have exceeded 730 hours, 500 hours being the economical requirement, and anything above this being in the nature of a gain in the original calculated efficiency of the system.

A simple description of the system as installed is as follows: The transmitted energy in the form of 10,000-volt, 3-phase, 33-cycle current enters constant-current transformers, each transformer being of single-phase design, the primary of which is wound for 10,000 volts and the secondary for 22,000 volts (open circuit). In the secondary is a centre connection for the rectifier.

The mercury arc rectifier is mounted upon a switchboard panel directly above the oil switch. It is excited by a small amount of 115-volt alternating-current energy. This is sufficient to start the rectifier after the same has been moved slightly with a handle for that purpose in order to establish the mercury arc. It requires but a few seconds to start up a circuit, and, when once started, it is not necessary to maintain the exciting circuit in operation, although this has been the practice up to the present time. In each side of the alternating current of the transformer is placed a reactance and another in the direct-current side. The lamps themselves require four amperes at an average of about 80 volts, or 320 watts, and give an equal illumination to the old-type open lamp requiring 500 watts. As the original distributing system was installed for 10-ampere lamps, losses in these conductors have of course been reduced to a minimum. The present lamps are installed in units of 75 lights. An extra transformer panel with rectifier is provided, so that in the case of any accident happening to the transformer or rectifier the circuit can immediately be plugged in on the spare set. The lamps themselves are, no doubt, familiar to many, having been described in some of the technical papers.

The efficiency of the rotary transformer motor-generator system, as originally installed in Portland to take care of the street arc lighting, from the alternating-current transmitted energy to the direct-current energy distributed to the lamps, was 62 per cent at or near full load (which is the prevailing condition).

The efficiency of the constant-current transformer mercury arc rectifier system from the alternating-current transmitted energy to the direct-current energy distributed to the lamps is at full load 88 per cent (at 10 per cent overload, 89 per cent); at three-quarter load, 85 per cent; at half-load, 81 per cent, and at one-quarter load, 80 per cent. This efficiency was obtained by measuring the true watt input of the primary alternating-current energy and the true watt output in direct current, and includes all transformers and reactances, and the small fan motor used to cool the rectifier tube.

Having thus effected a saving of 26 per cent in the efficiency of the transforming system itself in Portland, the company secured further economy by the use of magnetite lamps, using 320 watts in the lamp in place of the 500 watts, thus obtaining

for 364 watts of transmitted energy the same illumination that originally required 806 watts, or a saving of 1768 kilowatt-hours per lamp per year; or on the total Portland installation a saving in capacity of 531 kilowatts, and a saving in total energy of 2,121,600 kilowatt-hours per year.

The efficiency of a standard motor-generator set using a high-voltage motor and direct-current arc generator is about 76 per cent, so that if in a modern installation where low-frequency alternating current is transformed by synchronous motor arc machines into direct-current energy for present type of 500-watt arc lamps, there should be installed the constant-current transformer mercury arc rectifier system with magnetite lamps, the gain in efficiency for the same illumination would amount to 294 watts per lamp or 1176 kilowatt-hours per lamp per year.

The high commercial efficiency of the latter system is due to a very large extent to the simplicity and economy of the rectifier tube itself. A tube of a capacity of about 30 kilowatts has a constant loss of but 25 volts or, at four amperes, 100 watts per hour, while the cost of renewing the tube on the basis of 500 hours' life about equals the cost of labor and renewals on a motor-generator set.

Owing to the fact that both parts of the alternating-current waves are used, the voltage of the alternating current leaving the transformers to the rectifier tube to produce a desired voltage in distributed direct current must be about three times the desired direct-current voltage required by the lamps in circuit. Thus, about 22,000 volts on the secondary of the transformer tubes gives a direct-current voltage of about 7000.

In the use of the magnetite system a commercial question arises which, after very careful consideration, should be definitely answered before the system is adopted to any great extent. I refer to the specifications used in the present public lighting contracts. About fifteen years ago considerable thought was given to the subject by this association, resulting in a campaign of public education which produced the proper result at that time of rating street arc lamps by the "watts in the arc" and dropping out of contracts the term "nominal candle-power." If the price of public lighting is to be fixed by "watts in the arc" on the same basis as present cost, the public will profit by this

lamp (due to lamp efficiency) to the extent of 36 per cent, the company gaining in transformer efficiency to an extent of 17 per cent.

The question as to how the public and the companies should share this gain and how to determine under what specifications the illumination should be furnished is a broad one and is a matter that should be carefully considered at this time so that the introduction of this new system shall be accompanied by a proper standard form of specifications.

DISCUSSION

MR. J. HENRY HALLBERG (New York City): Mr. Barstow stated that the cost of renewal and maintenance for the mercury tubes is about the same as the cost of repairs and maintenance of the motor-generator set. I should like to know the exact cost of these tubes for such an outfit as Mr. Barstow describes in his paper.

MR. BARSTOW: The minimum cost of the tube is $15—that is, for a 75-light set—and the cost of the tube about balances the labor of attendance and renewals on the motor-generator set. The labor cost is very small on the mercury arc rectifier system, one attendant easily taking care of a 1200-light installation as well as of the other apparatus in the station.

MR. HALLBERG: How does the investment for the magnetite system compare with other standard arc-lighting systems? Taking into consideration the saving of something like 30 per cent of the original capacity of the plant, do you come out even or ahead with the additional investment that may be necessary for the magnetite system, which is still not in extensive use and therefore comparatively expensive to install?

MR. BARSTOW: The cost of the transformer, mercury arc rectifier, switchboard panels and reactances, which are really the transforming apparatus, is just about the same as that of a motor-generator set. No credit has been given the system in this paper for any saving on the original investment of the generating plant, the devices being considered simply as a piece of transforming apparatus.

MR. P. D. WAGONER (Schenectady, N. Y.): I wish to correct the impression that might be given by Mr. Barstow's remark in regard to the cost of the tube. The figure that Mr.

Barstow mentions is a figure that was arrived at when the industry was very young and when very incomplete data were obtainable as to the exact cost of manufacture. Accurate information on this point would be to say that the price of the four-ampere tube is $25, with a $5.00 rebate for the return of the old tube, prepaid for salvage. I think the important consideration, however, is the maintenance per circuit per year, from the tube standpoint. The figure that we ordinarily consider for life of tube is 400 hours, which on an average circuit would be ten tubes per year; at a net price of $20, $200 per circuit per year, which, even on a 50-light circuit, would be only $4.00 per lamp per year. Usually, the other economies, which Mr. Barstow mentioned in his paper, are so great that the cost of tube renewal becomes an insignificant quantity in the consideration of a particular installation.

I should also like to say a word or two in connection with the specifications to be placed in city contracts. It may possibly be of interest to the association to know the plan that has been worked out in a few instances. I have in mind one instance where the city contract reads that lamps may be furnished which will give an illumination equal to a lamp of 500 watts or to the old-time nominal 2000-cp lamp. Another method, which has been used, I think, more frequently than any other one method, is to base the city contract on luminometer readings. I think you are all familiar with the luminometer. The city contract is based upon reading a certain line on the luminometer card at a certain distance from the lamp. I have in mind one other city contract that has been closed where the wording was simply that lamps should be furnished giving as good illumination as the lamps then operating on the street circuits.

I want to say a word in connection with the character of illumination with the magnetite lamp, and that is that, due to the fact that the light comes from the arc itself, the distribution of illumination for street lighting is much better than that of a lamp in which the light comes from the crater, although the latter lamp may give the same total spherical candle-power.

It is possibly of some interest to the association to remind you that in the paper that I read last year on the mercury arc rectifier I mentioned the rectifier-magnetite system as a possibility of the future. That possibility has now been realized.

MR. WILLIAMS: In view of the fact that several new types of illumination for street lighting have been brought to our attention and are available for that purpose, it seems to me that this might be a very good time to take up the question of a new specification for municipal lighting. All will recall the time it took to whip into shape corresponding specifications which changed lighting standards from candle-power to watts at the arc. Now we have the flaming arc, the Nernst lamp, the magnetite, and possibly there will be other types in the future—lamps in which the watt consumption is materially lower than the present standard and the illuminating power materially higher—and it seems but fair that the specifications that have now become quite general should be modified so that the use of these lamps, which can be accomplished only with very large investment, should bring at least a part of the benefit to the supplying companies. If this could be done, a change in standard specifications would be necessary, and it might be timely for this association, Mr. President, to appoint a committee to consider the best means of accomplishing that result.

I should like to ask Mr. Barstow a question as to the performance of the magnetite lamps—how they act upon the circuit, whether or not they are more sensitive to line disturbances, whether he has had an increase in outages as compared with the standard type of enclosed lamps, and whether, in the sense of maintenance and inspection, the cost varies greatly from the present standard systems.

MR. BARSTOW: At the beginning of the installation of the magnetite lamp, considerable trouble developed with just the point mentioned—the outages were frequent and the performance of the lamp was very bad indeed. Upon testing a large number of lamps it was discovered that the mechanical part of the lamp was satisfactory and that the main trouble was in the magnetite sticks themselves. The magnetite sticks, as you know, are composed of a tube of sheet metal filled with the magnetite mixture. This was packed into the tubes by hand. It was found that the outages in the lamps were due to a button of slag forming on the magnetite stick, and this forming of slag, which insulated the contact and produced the outage, was due to the uneven packing of the magnetite mixture; in other words, in packing the stick by hand a certain amount of the mixture was

measured out to each workman and he was required to pack all of it in a certain space in the tube. In starting in to pack the stick, if the workman found he was running a little short of mixture he would pack the balance somewhat loosely; on the other hand, if he found he had some left over he would pack the balance very tightly, and this produced a stick of uneven character, which produced the slag that caused the outage. As soon as they began to manufacture in quantities and packing machines were used, this trouble disappeared to a large extent. The only trouble occasionally experienced now with the lamp is due to the defective manufacture of the sticks themselves; but these sticks, being manufactured in larger quantities, are becoming better and better, so that the outages and the inspection required at the present time are less than they were with the old-style system. The lamps have been satisfactory and there has been little trouble experienced lately, the principal difficulty being in the starting up of the lamps, owing to the fact that there is a metallic electrode which requires considerable time to heat up to form the arc as compared with the carbon electrode. This has been overcome by arranging for the transformer to give an increased voltage at the start, which runs the current up at the instant of starting so as to heat the stick quickly. Then the lamp settles down at the end of a few seconds and burns steadily.

THE PRESIDENT: Mr. Williams' suggestion is a very timely one and will probably be taken up after the discussion on the next paper.

MR. DUDLEY FARRAND (Newark, N. J.): I notice Mr. Barstow has a happy way of passing over the real difficulties of the problem. I ask him how the lamps are rated in Portland, in the contract. Say the lamps take 320 watts, what are the specifications as to candle-power or consumption? How do you get around that problem?

MR. BARSTOW: The problem of the specification is a serious one. Mr. Wagoner suggested the comparing of illumination from a magnetite lamp with that of the old lamp. I had the pleasure of trying that on two councils and it did not work—the councils saying that the reason they were putting in the new lamp was because the old lamp was not satisfactory, and they would not compare it with the old lamp in any way. The

only way in which this has been overcome was by showing the lamps burning side by side, showing the superiority of the magnetite lamp over the present form, and, in view of the installation of the new lamps, getting a release from the city engineer, or some one in authority, waiving that part of the agreement calling for the watts in the arc and placing it on a basis of satisfactory illumination. That is rather a makeshift proposition, and the question will, no doubt, prove a serious one when the lamps are more generally introduced. Up to the present time it has been a case of working on each installation very carefully and getting around it in the best way possible; but there should be very careful consideration given to this subject, as sooner or later it will be brought up by the municipalities themselves.

MR. C. A. S. HOWLETT (Chicago): Will Mr. Barstow tell us the difference in efficiency when using an alternating-current generator, transformers and the rectifier, as compared with the use of a direct-current arc machine to operate these lamps?

MR. BARSTOW: It will be about four per cent in favor of the alternating-current machine with the tub transformer. The efficiency is about 82 per cent in one case and 78 per cent in the other, due to the fact that the direct-current arc machine is not particularly high in efficiency. Of course, in comparing the two we should remember the fact that, even with a large installation, the size of your individual direct-current arc machine is still limited to small capacity, whereas with the alternating-current system you are enabled to use a very large unit for the generator. In that way, in a large installation you very soon begin to see the benefit of the alternating-current transformer system, due to the elimination of a large number of small arc sets.

THE PRESIDENT: Associated in a way with the magnetite arc lamp is the flaming arc lamp, and in introducing the gentleman who is to read a paper on this subject I take pleasure in greeting a sister organization, the Illuminating Engineering Society, of New York City, through its president, Mr. Louis B. Marks, who will read a paper on *The Flaming Carbon Arc Lamp.*

Mr. Marks read the following paper:

THE FLAMING CARBON ARC LAMP

(WITH SPECIAL REFERENCE TO ITS ADAPTABILITY TO STREET ILLUMINATION IN THE UNITED STATES)

Up to the year 1894 the only arc lamps used in the United States were those of the open arc type. In that year the commercial introduction of the enclosed arc lamp began and during the past ten years the gradual displacement of the open arc lamps by the enclosed arc has taken place. The manufacture of the open arc type of lamp as used in the United States was practically discontinued several years ago, and since that time the arc lamps made in this country have been almost exclusively of the enclosed arc type.

The mean spherical candle-power of the open arc, operated at its best, is almost double that of the enclosed arc taking the same power. In spite of this difference in the total light flux of the lamps the enclosed arc displaced the old open street arc mainly because of the following advantages of the former:

First—Decreased cost of carbons and maintenance.

Second—Greater steadiness.

Third—Better distribution of illumination.

The lighting interests now have offered for their consideration another lamp of the open arc type, popularly known as the flaming carbon arc lamp.

Let us examine briefly some of the characteristic differences between the flaming carbon arc, the ordinary open and the enclosed arc.

In the open arc lamp, as commonly used, the carbons are solid and comparatively free from impurity. The arc is about one-eighth of an inch long, and the light emanates almost entirely from the incandescent points, less than ten per cent coming from the arc itself.

In the enclosed arc the carbons must be as pure as possible. The arc, as ordinarily operated, is about three-eighths of an inch long, and as in the case of the open arc, most of the light issues from the incandescent carbon tips.

In the flaming arc lamp, on the other hand, the carbons are

cored and mineralized, that is to say, provided with certain mineral substances either in the core or body of the carbon or both, which, when feeding into the arc, greatly increase the light-giving

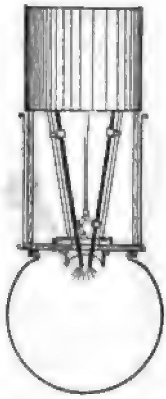


FIG. 1—GENERAL ARRANGEMENT OF PARTS OF FLAMING ARC LAMP WITH CARBONS FEEDING DOWNWARD

efficiency of the latter. The volatilization of the mineralized carbon produces fumes and a considerable quantity of ash, deposits

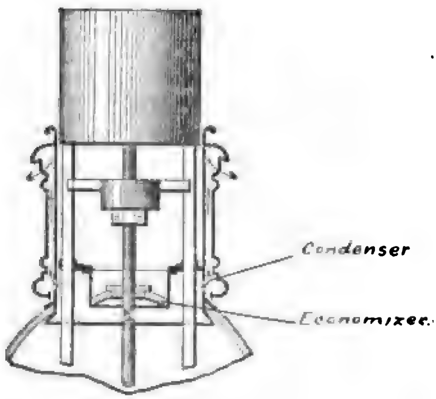


FIG. 2—FLAMING ARC LAMP WITH CARBONS CO-AXIALLY ARRANGED

of which are made largely in the portion of the lamp immediately above the arc. In the flaming arc lamp, unlike the open and the enclosed arcs, the bulk of the light emanates from the arc itself,

only a comparatively small portion coming from the carbon points. In the lamp with the carbons co-axially arranged (see illustration), the length of the arc is about five times that of the

FIG. 3—MAGNIFIED VIEW OF FLAMING ARC (POSITIVE CARBON UNDERNEATH)

ordinary open arc, taking the same current and voltage, or about five-eighths of an inch. When both carbons are arranged to feed from above, the arc tends to creep up the sides of the carbons

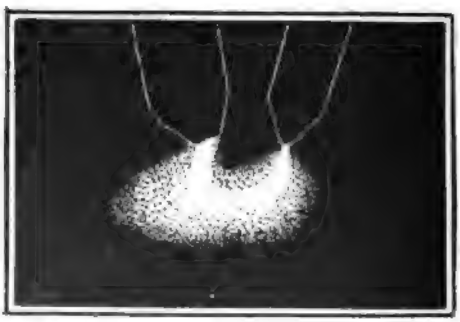


FIG. 4—FLAMING ARC BETWEEN INCLINED CARBONS (ARC BLOWN DOWNWARD BY MAGNET)

unless special provision is made for holding it in place, so that in all flaming arc lamps with inclined carbons, a magnetic field is provided in the lamp by which the arc is continuously blown down-

ward, resulting in a long flame measuring one inch to one and one-half inches in length. (See illustration.)

Owing to the rapidity with which the carbons are consumed in the flaming arc lamps it has been found necessary to shield the tips as far as possible from "washing" of the air currents in the globe. For this purpose an "economizer" (see illustration) or chamber of highly refractory material is used, which surrounds the ends of the carbons (in lamps in which the carbons are arranged side by side) or encircles the upper carbon (in lamps in which the carbons are arranged one above the other).

The vapor which results from the burning of the mineralized carbons condenses for the most part on the economizer and con-

FIG. 5—ECONOMIZER

tiguous portions of the lamp casing. Sometimes a special form of condenser is provided to receive the vapor deposits. As the color of the condensed vapor is whitish the deposits above the arc assist in reflecting the light downward. The arc is extremely sensitive to currents of air in the globe and to variations in the magnetic field and regulating mechanism of the lamp.

The regulating mechanism is housed as completely as possible to prevent access of the fine ash and the destructive fumes from the arc. It is not deemed necessary to give the details of the regulating mechanism of the various lamps of the flaming arc type, as in principle the mechanisms are the same as some of those of the older types of arc lamps, with which we are familiar. It

should be stated, however, that in most of the types of these lamps used abroad the mechanism is of the wheel and pinion type and far more complicated than that to which we are accustomed in lamps now used in the United States. In some of the more recent types of the flaming arc lamp the mechanism has been considerably simplified, but it remains to be seen whether the newer forms will meet the commercial requirements.

In Europe there are no less than ten different makes of flaming arc lamps on the market. Among these may be mentioned the Siemens, Koerting and Mathiesen (Excello), and Beck, which are now on the market in the United States. All three of these are of the inclined carbon design, both carbons feeding downward.

Bremer, who was the first to bring out a lamp of the flaming arc type, in 1898, found that when the carbons were impregnated or built up with substances suitable for augmenting the light-giving efficiency of the arc, such as salts of calcium, magnesium, *et cætera,* the scoria produced by the burning of the carbons, when the latter were placed one above the other, resulted in unsteadiness of the arc and liability to extinction. To overcome this difficulty he arranged the carbons side by side, both feeding downward, so that when the arc was formed between the tips of the carbon the molten scoria resulting from the volatilization of the foreign matter in the carbon would drop off without materially interfering with the action of the arc.

The Blondel lamp, in which the carbons are arranged one above the other, has met with considerable success abroad. In this lamp a specially constructed mineralized carbon is used, designed to overcome the difficulties resulting from the production of scoria which Bremer found in operating arcs with the carbons co-axially arranged. In the Blondel lamp the lower carbon (which contains practically all of the light-enriching salts) is somewhat larger in diameter than the upper. As the upper carbon in this case produces practically no scoria, the instability of the arc from this cause is minimized. In this type of lamp, the magnetic field, which is required with the inclined carbon lamps, is, of course, unnecessary.

Luminous Efficiency of the Flaming Carbon Arc—The following measurements are taken from a report of test made by the Electrical Testing Laboratories, New York, October 6, 1905, on a Koerting and Mathiesen flaming arc lamp, and on a standard

5-ampere single-globe enclosed arc lamp. The enclosing globe in each case was slightly opalescent.

	Flaming Arc Lamp	Enclosed Arc Lamp
Positive carbon (diameter)...	9 mm. (11/32 in.)	13 mm. (1/2 in.)
Negative carbon (diameter)..	8 mm.	13 mm.
Mean amperes	8.0	5.1
Mean volts at arc.............	45.0	81.0
Mean watts at arc............	360	413
Mean spherical candle-power..	1020	232
Watts per mean spherical candle-power	0.353	1.78

From these measurements it will be seen that the flaming arc lamp gives a little over five times the total luminous flux of the enclosed arc lamp using the same amount of power at the arc.

In the test of the flaming arc lamp just quoted, the carbons used contained calcium salts giving a yellowish-golden tint to the light. Carbons containing these salts produce the highest luminous efficiency in flaming arcs. It should be noted that when carbons (containing barium salts) producing a white light are employed, the luminous efficiency is materially decreased, the reduction amounting to from 25 to 40 per cent depending upon the character of the mineralization. When carbons (containing strontium salts) producing a reddish-pink light are employed the luminous efficiency lies about midway between that of the yellow and the white light.

Color of Light—For purposes of street illumination the highly efficient yellow light of the calcium carbon is in general suitable, but for interior illumination where color values are important the yellow light flaming carbon lamp is objectionable. Under the light of this lamp white material appears cream-colored, the shades of yellow are intensified, and the color values at the violet end of the spectrum are naturally distorted. It is quite impossible to distinguish different shades of dark blue from one another, all of them appearing black. With the white light flaming carbons, however, most of the colors have nearly their daylight value.

Steadiness of Light—In the very nature of things the tendency of a long arc operated in the manner employed in flaming arc lamps is toward unsteadiness. The variability of air currents in the globe, the lack of uniformity in the chemical constituency of the mineralized carbon, and the action of the magnetic field

(where such is employed),—these and other difficulties conspire to produce unsteadiness in the light.

Distribution of Illumination—The distribution of illumination of the type of flaming arc lamps now in use is quite different from that of the enclosed arc lamp. Most of the light of the flaming arc lamp is thrown downward in a zone from 30 to 90 degrees below the horizontal, the amount of illumination dropping off quickly toward the horizontal. Mr. W. D'A. Ryan reported recently on a series of tests of flaming carbon arc lamps showing that only about 15 per cent of the total luminous flux lies between the horizontal and 20 degrees below.*

The maximum illumination of the flaming arc lamp is at about 45 degrees below the horizontal, in which respect the distribution of its light resembles that of the old open arc. The flaming arc, however, sends its rays with almost equal brilliancy through all the angles from 30 to 75 degrees below the horizontal, while the old open arc quickly drops from its maximum on either side of the 45-degree line of vision, and yields a comparatively small proportion of its total flux between zero and 15 degrees below the horizontal. In the enclosed arc lamp, on the other hand, the horizontal illumination is relatively very large, and at 15 degrees below the horizontal the illumination is not far from the maximum.

In the following table are given enclosed and open arc candle-power measurements taken from the report of the committee for investigating the photometric value of arc lamps, and published in the National Electric Light Association Proceedings, 1902. The data are given for the angles immediately below the horizontal,—the important ones in street lighting.

In this table and accompanying chart the wattage stated refers to the power consumption at the arc. The voltage of the alternating-current arc was 70.7, the power factor being 0.85. The enclosed arc lamps were of the single globe type, the alternating-current arc being provided with a metallic shade. The globes were of opalescent glass, except for the open arc, which was bare. The candle-power measurements of the flaming arc lamps are taken from the test previously quoted in this paper; the globe of this lamp was of slightly opalescent glass.

* See Transactions, Illuminating Engineering Society, March, 1906.

DISTRIBUTION OF ILLUMINATION OF ENCLOSED ARC, OPEN ARC AND FLAMING CARBON ARC LAMP

	0° (Horizontal) Candle-Power	15° (Below Horizontal) Candle-Power	30° (Below Horizontal) Candle-Power
Alternating-current enclosed arc, 7.5-ampere (450 watts)................	312	375	445
Direct-current enclosed arc, 6.5-ampere (450 watts)	328	465	579
Direct-current, open arc, 9.5-ampere (450 watts)	195	598	1177
Direct-current flaming carbon arc, 8-ampere (360 watts)................	917	1312	1754

Taking the 6.5-ampere direct-current enclosed arc, it will be noted that from the horizontal down to about 12 degrees below, the enclosed arc gives more illumination than the 9.5 open arc consuming the same power. This means that if the lamps were mounted on poles 25 feet above the ground they would give equal illumination at a distance of about 115 feet from the pole; beyond this distance the advantage would be in favor of the enclosed arc. Now taking the case of the flaming arc lamp consuming 360 watts, or four-fifths of the energy of the enclosed arc, the illumination at a distance of 115 feet from the pole will figure out 2.83 times that of the enclosed arc.

From the distribution of illumination, as shown in the chart, it will be seen that this same proportion holds approximately for all distances from the pole greater than 45 feet, at which point the light strikes the ground at an angle of 30 degrees below the horizontal. At distances less than 45 feet from the pole the proportion rapidly changes in favor of the flaming arc and reaches approximately 10 to 1 at a distance of seven feet from the pole. With the 7.5-ampere alternating-current enclosed arc, the amount of illumination distributed through the most effective zone for street illumination is considerably less than that of the direct-current enclosed arc with the same power consumption. The ratio of 2.83 to 1 cited above, would for the flaming arc and the alternating-current enclosed arc be 3.3 to 1 at 12 degrees below the horizontal, representing a distance of 115 feet from the pole, 3.5 to 1 at 15 degrees below, representing a distance of 95 feet from the pole, and 3.9 to 1 at 30 degrees below, representing a distance of 45 feet from the pole. As in the last case, the proportion increases rapidly in favor of the flaming arc as we approach close to the pole. Hence if we are to obtain the most effective use

of the remarkably high luminous efficiency of the flaming arc lamp we must provide the lamp with a reflecting device that will materially modify the distribution of illumination of the arc. There is reason to believe that considerable improvement in this respect may be brought about but the problem is not a simple one. With the present distribution of illumination, the flaming arc lamp, if mounted on a pole having the same height as the poles now in use for street lighting, would produce an illumination in the immediate neighborhood of the pole entirely out of proportion to that given at a distance of 125 to 250 feet, which is about one-half the distance that now obtains between poles in arc lighting practice in this country.

To meet this difficulty it is apparent that unless the size

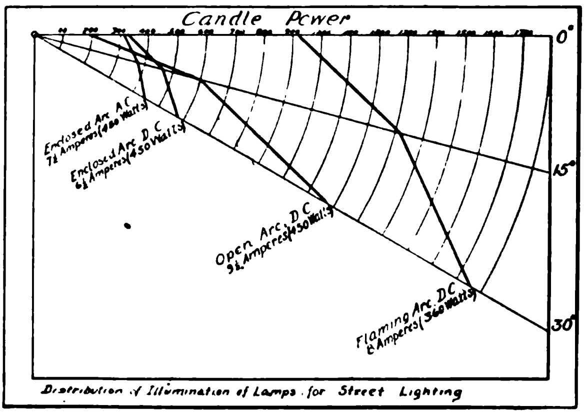


FIG. 6—DISTRIBUTION OF ILLUMINATION

of the unit can be materially decreased, the flaming arc lamp must be placed very high above the ground, so high in fact that in most cases serious questions arise as to the practicability of such a procedure.

Size of Units—The units now commonly employed are 8, 10 and 12 amperes with 45 to 50 volts at the arc. Owing to the special composition of the carbons and the peculiar nature of the arc, obstacles are encountered which make the practical operation of the lamp difficult when smaller currents are used. Professor Blondel writes to me under date of March 28, 1906, that the smallest practical currents for operating his lamp (before referred

to) are "from four to five amperes for direct current and from seven to eight amperes for alternating current." With small currents the luminous efficiency of the arc is very considerably reduced.

COST OF OPERATION

CASE I—STREET-LIGHTING CIRCUIT

In order to compare the cost of operation of the flaming arc lamp with that of the enclosed arc lamp now commonly used for street illumination in the United States I have taken the case of a lighting circuit in which the lamps are run all night every night in the year, on what is commonly known as the 4000-hour schedule. The present practice in street lighting is to place the poles on which the arc lamps are mounted, about 250 feet or more apart. Assuming that the flaming arc lamp gives five times the illumination of the enclosed arc for the same power consumption (which assumption strongly favors the flaming arc lamp so far as the illumination within the useful zone for street lighting is concerned, as has already been shown in this paper), it is obvious from the law of inverse squares that, for equal illumination midway between the poles, even if the flaming arc were mounted high enough up to give it the advantage of a more favorable distribution of light, it could not replace more than two enclosed arc lamps each consuming the same amount of power as the flaming arc. Taking a circuit of lamps where two enclosed arc lamps are thus replaced by one flaming arc lamp, the difference in the cost of carbons and maintenance is as follows:

STREET ARCS (500 WATTS) OPERATED 4000 HOURS A YEAR

COST OF CARBONS AND MAINTENANCE

	Two Enclosed Arcs	One Flaming Arc (Carbons 10 Cents per Trim)
Carbons	$2.86	$36.50
Trimming	2.34	8.21
Repairs	1.50	0.75
Inspection	0.90	0.90
Inner globes	0.60	....
Outer globes	0.30	0.15
	$8.50	$46.51

The cost of a pair of flaming carbons suitable for an all-night run is taken at 10 cents. It should be noted, however, that the lowest price now quoted in this country for carbons for such

service is 15 cents a pair in quantities. In the table which follows, the difference in cost of operation, should the price of carbons fall as low as two cents per trim (an extreme case), is given. The cost of the enclosed arc carbons is taken at 2.75 cents per trim, based on an average life of 77 hours per trim. This cost, it will be noted, is higher than that which obtains in most of the larger stations in the country. The enclosed arcs are assumed to be trimmed once a week, the stub of the upper carbon being used the succeeding week as a lower, which is the usual practice. The flaming arcs are trimmed once a day. The cost of trimming and cleaning the lamps is put at 2.25 cents per lamp, an average figure.

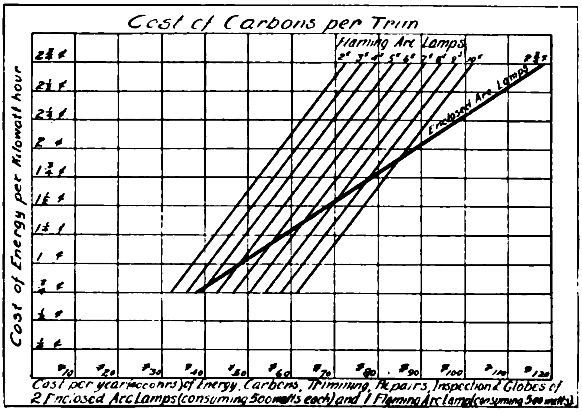
The cost of repairs per lamp is assumed to be the same in both cases, although with the present types of flaming arc lamps the cost of repairs would undoubtedly be very much higher than that of the enclosed arc. As bearing out this conclusion it may be stated that the cost of repairs of the old open-arc lamp now in use in this country is considerably higher than that of the enclosed arc. Mr. S. G. Rhodes, in a paper read at the convention of this association in 1904 (National Electric Light Association Proceedings, 1904, page 129), stated that on the circuits of the New York Edison Company operating enclosed arc lamps of the multiple direct-current and series alternating-current types, and series open arc lamps, the cost of repairs of 600 open arc lamps was as large as that of 2000 enclosed arcs.

The cost of inner globes for the enclosed arc lamps is figured at 15 cents each, two globes per lamp per year being allowed. As an offset against the cost of inner globes for enclosed arc lamps the cost of the "economizer" for the flaming arc lamp should undoubtedly be taken into consideration, but no allowance has been made for this destructible element in the flaming arc lamp. The cost of outer globes is figured at 45 cents each, the average life of a globe being taken as three years. In the flaming arc lamp the life of the globe would probably be considerably less than this.

The station cost of producing energy is taken at values from 0.75 cent to 2.75 cents per kilowatt-hour. This cost includes the cost of coal and water and that proportion of the station labor and maintenance account chargeable to the arc lighting system.

It will be noted from the table and chart that when the station cost of producing energy is less than two cents per kilo-

watt-hour, and the price of flaming arc carbons 10 cents per trim (which is one-third less than the present price in this country), it would not pay in this case to install the flaming arc even if the extra cost of new lamps and of installation of same be left



CASE I—STREET-LIGHTING CIRCUIT

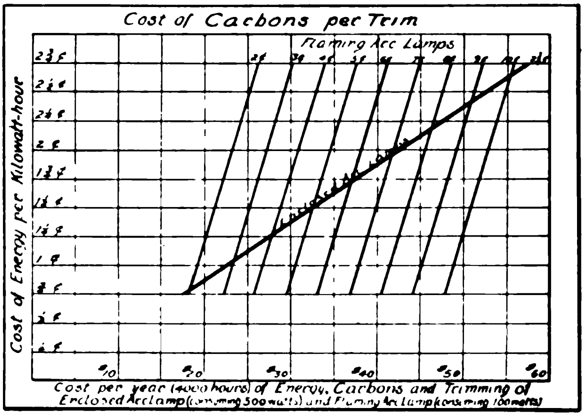
CASE I

STREET-LIGHTING CIRCUIT

Station Cost of Producing Energy per Kilowatt-Hour	Cost of Energy, Carbon, Trimming, Inspection, Repairs, Globes, 4000 Hours									
	Two Enclosed Arc Lamps (500 Watts Each)	One Flaming Arc Lamp (500 Watts)								
		Cost of Carbons per Trim								
	2¾c.	10c.	9c.	8c.	7c.	6c.	5c.	4c.	3c.	2c.
2¾c.	$118.50	$101.51	$97.86	$94.21	$90.56	$86.91	$83.26	$79.61	$75.96	$72.31
2½c.	108.50	96.51	92.86	89.21	85.56	81.91	78.26	74.61	70.96	67.31
2¼c.	98.50	91.51	87.86	84.21	80.56	76.91	73.26	69.61	65.96	62.31
2c.	88.50	86.51	82.86	79.21	75.56	71.91	68.26	64.61	60.96	57.31
1¾c.	78.50	81.51	77.86	74.21	70.56	66.91	63.26	59.61	55.96	52.31
1½c.	68.50	76.51	72.86	69.21	65.56	61.91	58.26	54.61	50.96	47.31
1¼c.	58.50	71.51	67.86	64.21	60.56	56.91	53.26	49.61	45.96	42.31
1c.	48.50	66.51	62.86	59.21	55.56	51.91	48.26	44.61	40.96	37.31
¾c.	38.50	61.51	57.86	54.21	50.56	46.91	43.26	39.61	35.96	32.31

out of consideration, and even though one flaming arc replace two enclosed arcs. When the cost of energy is high, however, the flaming arc lamp makes a more favorable showing than indicated above, particularly if the cost of carbons is reduced. For instance, at station cost of 2.75 cents per kilowatt-hour for energy,

the cost of operation of the two 500-watt enclosed arc lamps is \$118.50 per year, as against \$101.51 per year for one 500-watt flaming arc with carbons at 10 cents a pair, and as against \$83.26 with carbons at five cents a pair. On the other hand, if the station



CASE II—STREET-LIGHTING CIRCUIT

CASE II
STREET-LIGHTING CIRCUIT

Station Cost of Producing Energy per Kilowatt-Hour	Cost of Energy, 4000 Hours: One Enclosed Arc Lamp (500 Watts)	Cost of Energy, 4000 Hours: One Flaming Arc Lamp (100 Watts)	Cost of Energy, Carbons, Trimming, 4000 Hours: One Enclosed Arc Lamp (500 Watts)	One Flaming Arc Lamp (100 Watts)								
			Cost of Carbons per Trim									
			2¾c.	10c.	9c.	8c.	7c.	6c.	5c.	4c.	3c.	2c.
2¾c.	\$55	\$11	\$57.60	\$55.71	\$52.06	\$48.41	\$44.76	\$41.11	\$37.46	\$33.81	\$30.16	\$26.11
2½c.	50	10	52.60	54.71	51.06	47.41	43.76	40.11	36.46	32.81	29.16	25.11
2¼c.	45	9	47.60	53.71	50.06	46.41	42.76	39.11	35.46	31.81	28.16	24.11
2c.	40	8	42.60	52.71	49.06	45.41	41.76	38.11	34.46	30.81	27.16	23.11
1¾c.	35	7	37.60	51.71	48.06	44.41	40.76	37.11	33.46	29.81	26.16	22.11
1½c.	30	6	32.60	50.71	47.06	43.41	39.76	36.11	32.46	28.81	25.16	21.11
1¼c.	25	5	27.60	49.71	46.06	42.41	38.76	35.11	31.46	27.81	24.16	20.11
1c.	20	4	22.60	48.71	45.06	41.41	37.76	34.11	30.46	26.81	23.16	19.11
¾c.	15	3	17.60	47.71	44.06	40.41	36.76	33.11	29.46	25.81	22.16	18.11

cost of energy is very low, say 0.75 cent per kilowatt-hour, the cost of two enclosed arc lamps is \$38.50 per year as against \$61.51 per year for one flaming arc with carbons at 10 cents a pair, \$43.26 a year with carbons at five cents a pair, and \$33.31 with carbons at two cents a pair. The cost of operation per year of two

enclosed arcs and of one flaming arc for costs of energy and of carbons other than above stated may be readily obtained from the chart.

CASE II—STREET-LIGHTING CIRCUIT

It has already been stated that the flaming arc lamp is not at present commercially operative in small units. Let us take a hypothetical case and assume that it is feasible to operate a unit taking one-fifth of the power of the present enclosed arc lamp and giving the same amount of illumination as the latter. If now we replace each enclosed arc lamp of the circuit by such a flaming arc lamp consuming one-fifth of the power, we find the following costs of operation in the two cases, it being assumed that the cost of repairs, globes, cleaning and inspection will check up evenly against each other in both instances.

From the table and chart it is evident that, even waiving the cost of new lamps and expense of their installation, it would not pay in order to secure the same illumination in a street-lighting system in which the station cost of producing energy is one cent per kilowatt-hour (a practical case) to substitute flaming arc lamps taking only 100 watts for enclosed arc lamps taking 500 watts each, unless the price of carbons for the flaming arc falls below three cents a pair. At five cents a pair, which is one-third of the price now quoted in the United States (for the long-burning carbons) and somewhat lower than the lowest price quoted by the principal makers in Europe, the cost of operation per lamp per year in this supposed case would be $22.60 for the enclosed arc as against $30.46 for the flaming arc. The cost of operation per lamp per year for various costs of energy and of carbons is shown in the table and accompanying chart.

CASE III—COMMERCIAL OUTDOOR CIRCUIT

In this case the cost of operating a commercial outdoor circuit, with lamps burning on an average approximately three hours a day, or 1000 hours a year, equipped with the present type of flaming arc lamps, will be compared with the cost of operating a similar circuit equipped with enclosed arcs.

The cost of enclosed arc carbons per trim, cost of one trimming per lamp and the cost of repairs, inspection and globes per lamp per year are taken at the same figures as in the preceding

case. The enclosed arcs are trimmed 10 times for this service and the flaming arcs 83 times. The safe allowance under commercial conditions is taken as 100 hours per trim for the enclosed arc and 12 hours per trim for the flaming arc. Following are the data of cost of carbons and maintenance per lamp per year, figuring the cost of flaming arc carbons at 15 cents per trim (present cost):

COMMERCIAL OUTDOOR ARCS (500 WATTS) OPERATED 1000 HOURS A YEAR

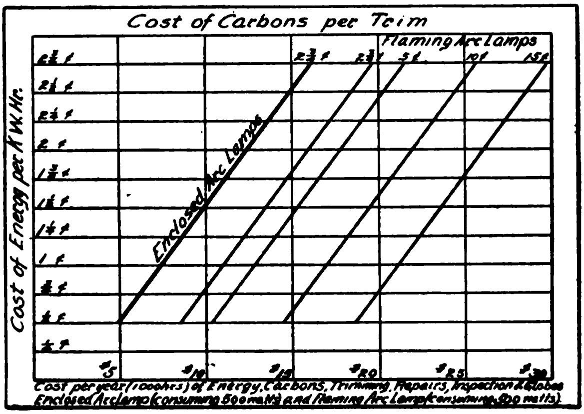
COST OF CARBONS AND MAINTENANCE

	Enclosed Arc	Flaming Arc (Carbons 15 Cents per Trim)
Carbons	$0.275	$12.45
Trimming	0.225	1.87
Repairs	0.75	0.75
Inspection	0.90	0.90
Inner globes	0.15	....
Outer globes	0.15	0.15
	$2.45	$16.12

The total cost of operation, including cost of energy (500 watts), cost of carbons, trimming, repairs, inspection and globes for both types of lamps is given in the accompanying table and chart.

Taking the cost of flaming arc carbons at 15 cents per trim (present cost) and the cost of energy at station-cost of one cent per kilowatt-hour, the cost of carbons and maintenance of the flaming arc lamp per year of 1000 hours under the assumption above made would be, as shown in the table and chart, $21.13, as against $7.45 for the enclosed arc. Hence, even waiving the additional cost of new lamp and installation, it would not pay from the standpoint of illumination to substitute the flaming arc for existing enclosed arcs under the above conditions unless the flaming arc lamps replace at least three enclosed arcs. Neither would it pay in the above case, with carbons at 10 cents per trim, the relative cost of operating the lamps here being $16.97 and $7.45. But with flaming carbons at five cents a trim, the relative costs of operation being $12.82 and $7.45, the substitution would pay if the flaming arc replaces at least two enclosed arcs. If the cost of flaming arc carbons were reduced to the present cost of enclosed arc carbons (2.75 cents per trim) the relative costs of operation would be $10.95 and $7.45, and in this case still it

would not pay to make the substitution unless at least two enclosed arcs are replaced by one flaming arc. From the table and chart



CASE III—COMMERCIAL OUTDOOR CIRCUIT

CASE III
COMMERCIAL OUTDOOR CIRCUIT

STATION COST OF PRODUCING ENERGY PER KILOWATT-HOUR	COST OF ENERGY, CARBONS, TRIMMING, INSPECTION, REPAIRS, GLOBES, 1000 HOURS				
	One Enclosed Arc Lamp (500 Watts)	One Flaming Arc Lamp (500 Watts)			
	Cost of Carbons per Trim				
	2¾c.	15c.	10c.	5c.	2¾c.
2¾c.	$16.20	$29.87	$25.72	$21.57	$19.70
2½c.	14.95	28.62	24.47	20.32	18.45
2¼c.	13.70	27.37	23.22	19.07	17.20
2c.	12.45	26.12	21.97	17.82	15.95
1¾c.	11.20	24.87	20.72	16.57	14.70
1½c.	9.95	23.62	19.47	15.32	13.45
1¼c.	8.70	22.37	18.22	14.07	12.20
1c.	7.45	21.12	16.97	12.82	10.95
¾c.	6.20	19.87	15.72	11.57	9.70
½c.	4.95	18.62	14.47	10.32	8.45

the comparative costs of operation for the various costs of energy and of carbons may be read.

In the statements just made, to the effect that it would not pay to make the substitution of the flaming arc for the enclosed

arc under the conditions named, it is, of course, understood that the station is selling energy at a uniform price per unit for both the enclosed arc and the flaming arc. If, however, the mean spherical candle-power produced per unit of energy is made the basis of comparison, the substitution of the flaming arc for the enclosed arc would pay in every case cited in the table, even at the present cost of flaming arc carbons. For instance, with energy at station cost of one cent per kilowatt-hour, the cost of current, carbon and maintenance of a flaming carbon arc is, as appears from the chart, nearly three times that of an enclosed arc taking the same power; but as the flaming arc for this power gives five times the mean spherical candle-power of the enclosed arc, the cost per candle-power of the former is only three-fifths that of the latter. But unless a very intense illumination in a small space is desired (as, for example, for advertising purposes), no advantage would be gained by substituting an intense light for one of smaller candle-power and less intrinsic brightness.

CONCLUSIONS

In summation, I conclude:

First—That the flaming carbon arc lamp of commerce produces five times the total luminous flux of the enclosed arc lamp for the same expenditure of electrical power in the arc.

Second—The lamp is well adapted for purposes of illumination where a flood of light is desirable in a single unit, as, for instance, for advertising purposes.

Third—The lamp may be used economically in the lighting of some large interiors, and in large open spaces, such as public squares and wide boulevards, if the lamps are placed at a considerable height, say 40 to 50 feet above the ground.

Fourth—The concentration of such a large flux of light in a single unit renders the lamp unsuitable for purposes of ordinary street illumination in the United States.

Fifth—The advantage of economical production of light is offset by reason of the necessity for frequent trimming with expensive carbons.

Sixth—The fumes and ash given out by the lamp, the unsteadiness of the light, and the objection to frequent trimming, render it unsuitable for most cases of interior illumination.

DISCUSSION

MR. WAGONER: I am very much interested in the paper read by Mr. Marks on flaming arc lamps, especially in the figures showing the effect on maintenance cost of high cost of carbons and short life. I think that in connection with that paper it would be of interest to note particularly that with the luminous magnetite lamp the cost of electrodes would be one-fortieth of the cost of carbons for the flaming arc lamp, taking the cost of the carbons at 15 cents for the flaming arc lamp.

MR. HALLBERG: There is one matter in connection with Mr. Barstow's paper that I do not believe was thoroughly appreciated, and that is the saving of something more than 500 kilowatts of station capacity in the Portland plant. Do you realize that this represents an investment of more than $50,000, taking the station cost at $100 per kilowatt, which is a small amount? An ordinary series enclosed arc system costs about $30 per lamp, or $36,000 for 1200 lamps. The magnetite arc lighting system, at $40 or $50 per lamp, would represent an investment of about $50,000. Taking for granted that the system operates satisfactorily and that a saving of $50,000 on the equipment of a station of the capacity mentioned can be made, how can any one afford to put in anything but the magnetite arc lighting system? Besides reducing the capacity of the power-house and transformer plant, the saving of about 30 per cent of the current over other systems is quite an item, representing in the case of the Portland plant 2,121,600 kilowatt-hours per year.

MR. T. S. PERKINS (Pittsburgh, Pa.): I should like to say a word in connection with Mr. Barstow's paper. As I understand the matter, the magnetite stick is deposited—or practically all deposited—as there are no gases formed in the burning of the stick. This, therefore, naturally brings up the question of this deposit, which in a fluffy condition must amount to considerable, and the point occurs as to how much of the deposit is carried clear of the lamp. I understand there is a chimney in the lamp, and if it is not thoroughly carried out the deposit would amount to considerable and would possibly be an annoyance; and further, no doubt, the amount of deposit that is carried depends on the air currents in the chimney and their control, and I believe that in some cases, where there are eddies due to obstructions at corners of streets, and so forth, it is more or less

difficult to get a lamp of this kind to burn with as good satisfaction as where the currents are more uniform.

What I should like to ask in the second place is, if this is looked upon as a serious matter, or is it felt that the lamp is sufficiently developed so that it can burn under circumstances where currents of air are such as to produce eddies and perhaps stronger drafts than are usually found.

Mr. Barstow: Mr. President, in answer to the last question of the gentleman, I understand it is in reference to the deposit in the lamp and also in reference to the currents of air. There is a gas given off by the lamp. The deposit is carried up through a specially constructed, ventilated chimney, which must be cleaned about once every 150 or 200 hours. When the stick is renewed the trimmer simply runs a chimney cleaner down through the chimney and removes the deposit.

With reference to the air currents I can say that the results show that there is no trouble with the present lamp. In the first lamp, as it was constructed, the designers did not pay particular attention to this and there was considerable trouble, as the lamp maintains a flaming arc which is sensitive to any air current. With the new form of ventilator there is now, with over a thousand lamps in use at the present time, under all conditions, very little trouble experienced in this line.

The remark of Mr. Hallberg in reference to the efficiency of the system is absolutely correct. There are a lot of indirect results which make the system, you might almost say, enormously efficient as compared with the old-style system. But in this paper just the transforming apparatus itself is considered and no credit is given to the generating capacity or to any other part of the system. I think particular attention should be given to the mercury arc rectifier part of the apparatus as well as to the magnetite lamp, as that, in my opinion, is one of the greatest developments we have had—a means of transforming alternating current of low frequency, on which you can not do any arc lighting, into direct current and at a very high efficiency.

Mr. Williams: Referring to the able paper of Mr. Marks' on the flaming arc lamp, I was very much surprised while in London last summer, shortly after our meeting last year, to see the extent to which the flaming arc lamp of various types has become a feature of the lighting system of that city. Two years

before there were but few of these lamps in the streets of London. Last year the number had enormously increased, giving the impression that the flaming arc lamp, whatever may be the additional cost of the carbons, is coming to be a popular lighting feature for advertising purposes. I saw a somewhat similar, though less notable, effect at Paris. There the flaming arc lamp is used to a large extent for illumination in the parks, and the effect of the colored light among the green foliage is strikingly beautiful. I have heard from those who have been at Berlin that the lamp is even more prominent upon the streets and avenues of that city—that its growth in Europe has been simply remarkable and the people look forward here to a similar demand in this country. One will readily appreciate, the lamp is so brilliant, that if placed near electric signs the great volume of light is apt to lessen the brilliancy of the signs. This harmful effect can be greatly lessened by getting the users of the flaming arc to hang the lamps rather high in the air.

The President: In his previous remarks, Mr. Williams brought out an important point, which is as to the practical way of modifying our existing contracts so that the introduction of the new types of lamps may be made possible. I have seen a paragraph inserted in various contracts, and have just jotted it down from memory, thinking it might be worthy your consideration. It is about as follows: "When on account of progress in the art new and improved lamps are available, the company may substitute them for those now in use if in the opinion of the city electrician, or a duly appointed representative of the city government, the new lamps give equal illumination along the streets of the city." I have known of several cases where this paragraph has been used with success.

Mr. Samuel Scovil: Mr. Marks made a special point of the cost of the carbon, and I should like to know what in his judgment is the probability of the cost of the carbons being materially reduced. No doubt he remembers what the cost of the original electric light carbons was and what the cost is to-day. What, in his judgment, will be the cost of these special carbons for these lamps when they come to be made in large numbers?

Mr. Marks: There is a great temptation in this particular field to speculate on possibilities when such rapid changes are

being made in all directions. If you refer to a carbon such as the Blondel carbon, I fear very much that we can not look for any great reduction in price below what the present price is in Europe, namely, six or seven cents a pair. It is necessary, in my opinion, to build up a carbon very carefully for good work. The ordinary cored carbon will not give the results we are after. During the years 1890 to 1893 I had considerable experience in a carbon factory and endeavored at that time to make an ordinary enclosed-arc carbon. We worked at it quite a while. It was in the works of the Washington Carbon Company. The National Carbon Company worked at it quite a while, too, and it took years to get at the present type, which is selling all the way from $27.50 per 1000 for half-inch carbons down to perhaps $5.00 or $6.00 less. In the case of the flaming arc carbon we have a different proposition. As I brought out in the paper, you must have absolute homogeneity. You have a foreign substance which is giving you the light and you have to place this substance in the carbon in exactly the right way to get good results; you have to build the carbon up, so to speak, so that, so far as the carbon expense is concerned, I do not personally look for any great reduction below the present prices existing in Europe.

With regard to Mr. Williams' statement of foreign practice, I also had the pleasure of visiting various cities in which the flaming arc is used. Regarding the use of the flaming arc in London, it seems to me that London is really a splendid place for the use of the flaming arc for street lighting, if the lamps are mounted high up, as they are in most cases. Take it along the Strand and Fleet street, up to Ludgate Circus, you find the lamps pretty well up in the air. The same thing is true of Piccadilly Circus. There they have atmospheric conditions that are very hard on the ordinary enclosed-arc lamp; the yellow ray of the flaming arc is just the thing to penetrate the London fog.

In my opinion, the lamp will undoubtedly have an application for lighthouse use. Its fog-penetrating power is wonderful. The enclosed arc for this purpose is not in it.

So far as the height of the lamp is concerned, the same remarks hold for Berlin. In *Unter den Linden* they have these lamps high up, sending their golden rays down on this

big square, and the illumination is very fine; but, comparing the cost of labor and carbons here—conditions are so different here—it would be an expensive matter for us to do the same thing. There is a great difference in the cost of carbons and in the cost of current. In Paris they charge the small users 20 cents a kilowatt-hour for current, hence it will pay them to use the flaming arc. Again, in this case there is the difference in the price of labor. We can not compete over here with that sort of thing, even laying aside the question of carbon cost.

Regarding the complication of the mechanism, I believe the lamp in this respect will certainly show a very considerable improvement and cheapening. We have flaming arc lamps on the market now in this country that are being sold for $30. On the other side the Braulik lamp sells for $24 and the Juno lamp sells for about the same price. They also have a magazine lamp, with the carbons side by side to get a longer life. In this country, where we have been through the magazine lamp experiments several times, I think the arc lamp manufacturers are not looking for any radical improvements in this direction. So far as long life is concerned—the point we want to reach—it does not look very encouraging in the flaming carbon arc type of lamp.

MR. SCOVIL: I move that the secretary appoint a committee to consider the president's address, to make such recommendations thereto as it may deem advisable.

(The motion was carried.)

THE SECRETARY: I will announce as the committee to consider the president's address the following-named gentlemen: Mr. Samuel Scovil, Mr. Arthur Williams and Mr. T. C. Martin.

MR. SCOVIL: I move that the president appoint a committee to consider the specifications for street lighting, to suggest some modifications of the requirements that are embodied in specifications for street lighting as they now exist, and to report as soon as possible.

(The motion was carried.)

The meeting adjourned until two o'clock.

SECOND SESSION

President Blood called the meeting to order at twenty minutes after two and announced the first business to be the report of the committee on steam turbines, Mr. W. C. L. Eglin, chairman. Mr. Eglin read the report of the committee, Mr. Moultrop reading the report embodying the results of his investigations abroad.

Mr. Eglin presented the following report:

REPORT OF THE COMMITTEE FOR THE INVESTIGATION OF THE STEAM TURBINE

Mr. President and Members of the National Electric Light Association:

Your committee has held a number of meetings during the past year and has discussed the various matters that have come before it, both as to the development and manufacture of steam turbines and the experiences gained from those in operation.

The turbine situation has very materially changed since our first report. To-day the steam turbine is recognized as a standard piece of apparatus, and turbines of some type are being installed in nearly all of the newer power-houses. Turbines have been installed in a number of steamships built in Europe, and, we are informed, have been approved by the commission appointed by the British Navy for use in its battleships and cruisers. Although steam turbines for marine use are outside of the scope of this committee's investigation, it is interesting to note, however, that after a trial on merchant vessels of the Cunard Line, they are being introduced into new ships of the same line. This would indicate that confidence is placed in this type of prime mover by the engineers.

During the discussion at the meetings of the committee it was decided that it was unnecessary to continue any further tests on economy, as there were now so many turbines installed in regular operation giving satisfactory results; and the most important matters receiving attention were the various details which go to make up reliability and insure continuity of service.

The committee decided to visit the works of the manufacturers again this year, as it was thought the greatest benefit could be obtained for the association by a full and free discussion with the engineers of the manufacturing companies covering all of the information in the hands of the committee concerning the turbines built by the several manufacturers.

The committee met in Boston, Tuesday, April 3, and at this meeting arranged the programme to be carried out, and also the list of subjects to be discussed with the various manufacturers.

MANUFACTURERS OF THE CURTIS TURBINE

Later in the day a visit was made to the Lynn works of the General Electric Company. The committee was received by Mr. Richard·H. Rice, with whom the various features of the Curtis turbine were discussed with particular reference to changes in design from the time of the last visit of the committee to the Lynn works. The committee was shown through the works. The most important feature is the large increase in the number of the smaller sizes of turbines now being built, sizes from 25 to 300-kw of the horizontal Curtis type. A number of these turbines were being controlled by a mechanical valve mechanism of a new type, being developed specially for this class of turbine.

There was a very noticeable increase in the number of turbines being manufactured in sizes up to 1500-kw, as well as the smaller types.

The works of the General Electric Company at Schenectady were visited on the following day. The first part of the day was devoted to inspection of the works and the latter part to discussion of details with the engineers of the company. During the inspection of the works a number of improvements in the mechanical construction were noted. The larger wheels in some cases are being made from steel plates or boiler plates, two plates being bolted to a spider, the spider being placed between the plates and the buckets riveted at the outer edge with the flange of the bucket sections on the inside of the wheel; the two sets of buckets are so arranged that they have a smooth external surface, reducing the friction of the wheel.

Your committee discussed with the engineers of the General Electric Company, both at Lynn and Schenectady, the various features of the Curtis turbine, and particularly such parts as had required special attention during the past year in regular operation. These were taken up in the following order:

First—The mechanical valve gear.

There are now being manufactured three distinct forms of mechanical valve gear. First, the valve gear as described in our previous report, designed by Mr. Richard H. Rice, has had some improvements added.

The hydraulic mechanism, described in our last report, has been introduced into some of the largest sizes of turbines with

satisfactory results. On the smaller-sized machines a single cylinder is used to operate all of the valves, and in the larger sizes two cylinders are used. The single cylinder is now recommended for all sizes. This cylinder will be so proportioned that it may operate from the regular gravity oil supply when specified.

The manufacturer's description of the changes in the mechanical valve gear is as follows:

The purely mechanical type of valve gear in use on vertical General Electric Company turbines of Lynn manufacture and of design subsequent to that described in last year's report, differs from that design in certain particulars, but retains its general features. The changes have been in the interests of simplification,

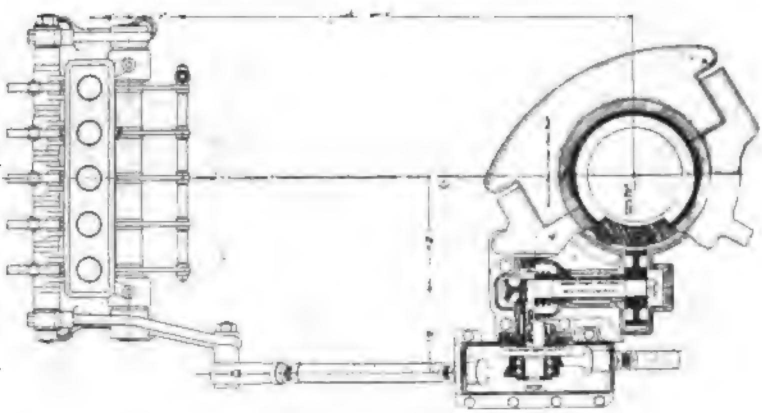


FIG. 1—PLAN OF MECHANICAL VALVE GEAR OF CURTIS TURBINE

elimination of noise from the gear drive, and improvement of appearance; and with these three major changes are incorporated such changes of minor details as experience has dictated. The gear still consists of a number of units, each operating a valve in such manner that, except momentarily, it is always wide open or quite closed. Each unit consists as before of a pair of reciprocating pawls, one adapted to open the valve the other to close it; a governor-controlled shield-plate, which determines as before by its angular position the engagement of one or the other pawl and consequently the opening or closing of the valve; and the valve itself with stem and cross-head. All the pairs of pawls are reciprocated in unison by a common moving support suitably driven

from the turbine shaft. Thus far the description would apply to the older or the newer form alike.

Coming now to the differences:

First, the reciprocating connecting-rods actuating the pawls in the later form are driven by worm gearing located near the middle of the shaft instead of near the top, thus rendering the driving parts simpler and less conspicuous.

Second, the pawls, instead of engaging a cam-plate, which in turn actuates the cross-head of the valve, engage this cross-head directly, thereby much reducing the number of parts and the linear motion required of the pawls.

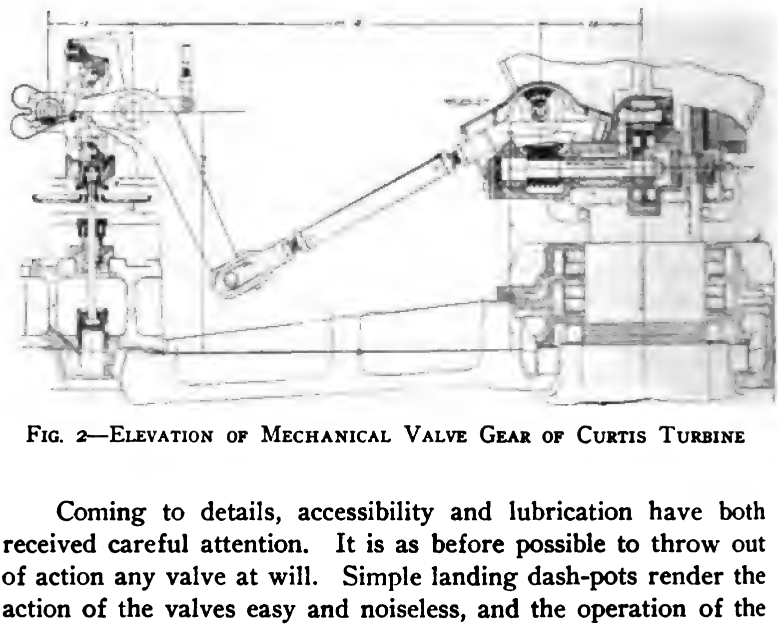


FIG. 2—ELEVATION OF MECHANICAL VALVE GEAR OF CURTIS TURBINE

Coming to details, accessibility and lubrication have both received careful attention. It is as before possible to throw out of action any valve at will. Simple landing dash-pots render the action of the valves easy and noiseless, and the operation of the worm gearing is absolutely noiseless. All large reciprocating parts are removed from immediate view, and by the reduction of the stroke of these parts the very considerable inertia work on the driving worm is much reduced. At some other points further slight changes of detail have been made by which it is believed that simplification and general betterment have been effected.

In brief, it is hoped that the newer gear will be found to retain the merits of the older, and to surpass it in simplicity, com-

prehensibility, quietness, appearance, and in lesser details making for durability.

NEW MECHANICAL GEAR USED ON SMALLER-SIZE TURBINES

This gear consists of a system of units, each unit consisting of two elements: First, a valve with cross-head and block, and second, an actuating dog capable of opening or closing the valve through engaging the block, and driven at reduced speed from the turbine shaft. Each valve has but two positions of rest—wide open and entirely closed. The system of operation is in this respect that at present used on the larger Lynn machines.

The dog itself consists of a small eccentric strap with projecting arm about six inches long, provided with two hooks, one at its outer extremity, adapted to pull the cross-head block toward the eccentric shaft and open the valve, and the other located half-way between the one first named and the shaft, adapted when suitably engaged to push the cross-head block away from the shaft and close the valve. The diagram shows the shape of this dog, its relations to the block and cross-head, and the relation of that to the valve.

The eccentric shaft, viewed as in the diagram, runs counter-clockwise, and by it is imparted to the dog a motion circular at one end and at other points determined by a composition of this circular motion with the generally rectilinear movement of the engaged element. The block is provided with two shelves or landing-springs, seen in both diagrams, and these determine the engagement of the opening or of the closing-hook. It will be seen that a displacement of the dog along the axis of the eccentric shaft will cause it to come in line with one or the other of these landing-springs. If it engages with the one nearer the valve, the hook at the outer extremity will engage when the dog is in its forward position. As the circularly-driven end swings downward and backward this hook pulls the block back and the valve opens. When it reaches its rear dead point the opening-hook, still resting upon the valve-end landing-spring, acts as a fulcrum and the upward movement of the eccentric causes the closing-hook, pivoting about this valve-end landing-spring, to rise so that it misses its connection with the block and does not close the valve. Conversely, if through axial motion the other way the dog lands upon the shaft-end landing-spring at the end of the outward

movement of the eccentric, the upward and forward movement of the closing-hook will close the valve, and the dog, pivoting about this shaft-end landing-spring, will miss connection with the opening end of the block and will therefore leave the valve closed. It will thus be seen that it is merely necessary for the governor to move the dog along the direction of the eccentric shaft axis in order to cause it to open or close the valve. It is interesting to note that the principal movements of this gear—working, clearing and governing—make use of the three dimensions of space. Friction load on the governor is almost completely eliminated by the fact that the parts which have to be moved endwise by the governor are revolving in their bearings. A straw taken from a broom will suffice to move the 100-kw valve gear back and forth.

Some further details arising directly from the design are as follows: The full width of the engaging knife edges is always employed; the only impact is upon landing-springs of the simplest form and adapted to receive it; within limits set by mechanical clearance it is impossible for the valve to move forward or backward under influence of steam more rapidly than the gear drives it; and the parts employed are very few, simple and substantial.

In case this gear is used in a horizontal position, gravity pulls the dog toward the blocks and in addition the friction of the rotating eccentric aids this action. In case the gear were to be used in a vertical position a slight endwise clamping of the dogs, accentuating the tendency of the shaft to carry them around in the proper direction, is sufficient to render the action certain without the intervention of gravity. The gear has thus far been actually used in a horizontal position only.

Second—There have been some minor changes in the buckets. The principal change in this direction is the increase in speed over the former speeds of the buckets; 325 to 350 feet per second is being increased in some cases to between 450 and 460 feet per second. The attached list gives the shaft speed and the bucket speed for each size.

Third—A lengthy discussion was held on the relative advantages of oil or water for step-bearings. It is the consensus of opinion that water is most desirable, although special care should be taken that the water is clean and free from grit of any kind. Oil will give better all-round results, and in future designs the step-bearing will be outside the casing for oil-bearings.

The step-bearing as so placed with the packing above it is accessible without opening the base, and with this arrangement a single oil pump will take care of the step-bearing, upper bearing and hydraulic valve mechanism.

When water is used for the step-bearing a wood-lined sleeve is recommended for the bearings, but when oil is used a babbitt-lined sleeve is recommended.

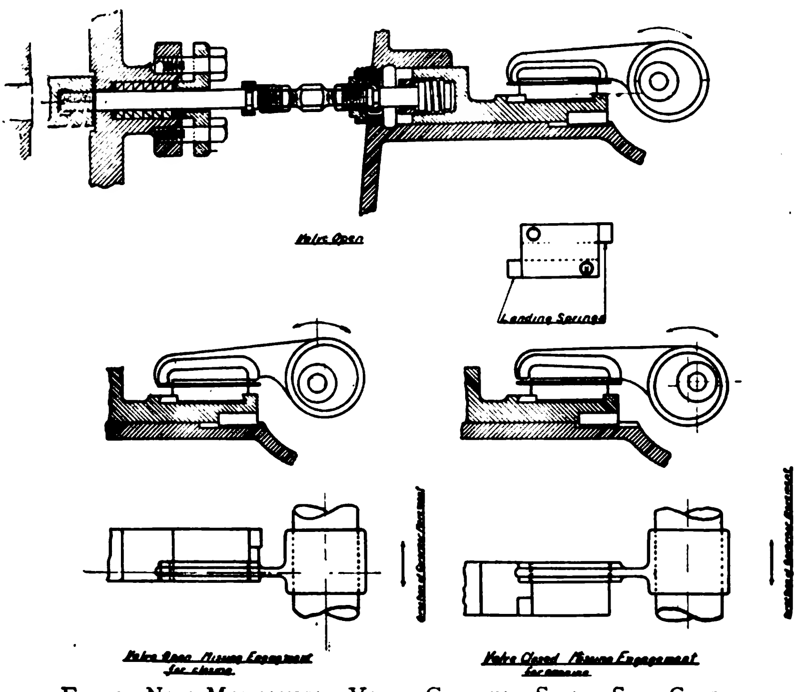


FIG. 3—NEW MECHANICAL VALVE GEAR FOR SMALL-SIZE CURTIS TURBINES

Fourth—At our last meeting with the engineers of this company the clearance between the buckets was discussed at some length, and the opinion was then expressed that the clearance of practical limits had no effect on the efficiency. It has been demonstrated that this clearance can be increased with advantage, and we have requested the company to consider increasing the clearance on all sizes, and we append herewith a list of revised clearances.

Turbine	Clearances			
	First Stage	Second Stage	Third Stage	Fourth or Fifth Stage
500-kw, 1905	0.6 inch	0.6 inch	0.6 inch	0.6 inch
500-kw, 1906	0.10 "	0.10 "	0 10 "	0.15 "
5000-kw, 1905	0.10 "	0.10 "	0.10 "	0.20 "
8000-kw, 1906	0.20 "	0.20 "	0.20 "	0.28 "

Note—The clearances of sizes of turbines between 500-kw and 8000-kw will vary between the limits shown.

Fifth—We also discussed the question of testing turbines, condensing and non-condensing. This does not appear to be practicable at the present time in the works of the manufacturers, so we recommend to all purchasers that before turbines are put into regular service they be tested both condensing and non-condensing, not for the purpose of determining the steam economy, but only to test the mechanical parts.

Sixth—The steam packing of the middle bearing has not proven entirely satisfactory and the design of this has been changed.

Seventh—The emergency stop now used consists of a ring which is slightly unbalanced and normally held in concentric position by a spiral spring. When the speed increases beyond the predetermined limit, the unbalancing overcomes the spring, and the ring flies into an eccentric position where it delivers a blow to a lever which trips the automatic stop valve. This device is very simple and positive.

Eighth—We were unable to suggest any changes in the casing which would improve its tightness without interfering with other functions, particularly the inability to remove sections for inspection. The prevailing opinion was that the best remedy was to examine the casing carefully after the turbines were set up and test for tightness by means of vacuum, marking all leaks, using a filler of paint or wax applied hot and when the casing is still under a vacuum.

Ninth—The changes in the balance after the turbines were in operation have been shown to exist in a great many turbines. This seems to be common to all types of turbines. Apparently this is in almost all cases attributed to the generator, the insulation between the conductors being primarily responsible.

All manufacturers are giving special attention to the design of the revolving field generator. The General Electric Company has developed a design of field with distributed winding which apparently will overcome these difficulties.

The new field structure that has been developed has been designed with distributed windings, with open spaces near the shaft, so that air can be received along the shaft and discharged by centrifugal force through the field laminations, and thus impelled through the armature laminations; the space at the ends being con-

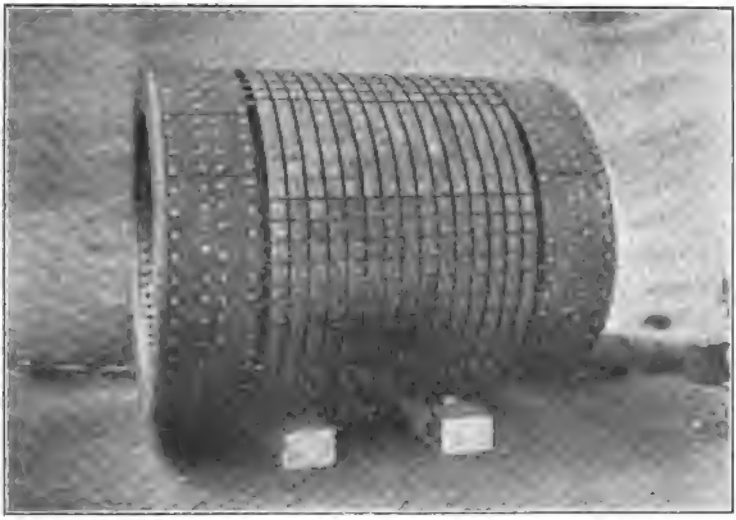


FIG. 4—NEW REVOLVING-FIELD CONSTRUCTION—CURTIS TURBINE

fined and arranged in such a manner that the air is positively forced through the inside outward. This air can be admitted at either end of the field, the intention being to close up the other end of the field so that air is all taken from one end. The armature frame has no openings on its outer surface. The space between the laminations and frame at the end where the air is admitted to the field is closed up. The air passes through the field and armature, and then passes out at the end opposite that from which it has entered. Its flow is governed by a powerful centrifugal impulse, and it will consequently be possible to connect

these machines by long pipes, if necessary, to points where cool air can be obtained; no blower being required in such pipes. As a rule, it will simply be desirable to extend such pipes to some low level in the station, where the air is naturally cooler than it is above turbines and steam pipes. These generators, having smooth rotors and no direct air communication outward, should be entirely free from noise.

This construction possesses the further advantage of being very strong, having weights very well distributed, and having everything in such a state of compression that no possible variation of balance can occur after the machine is in operation.

Another advantage is that the field coils are completely covered with insulation so that accumulations of dirt can not endanger them through surface leakages.

The revolving fields are now mounted with two keys, one at each end of the shaft, so as to prevent twisting of the keys which has interfered with the removal of the field from the shaft.

Standard sizes and bucket speeds of the Curtis turbine are as follows:

60-Cycle Turbines

Poles	Kw	R.P.M.	Bucket Speeds
4	300	1800	400
4	500	1800	400
6	1000	1200	416
8	1500	900	400
8	2250	900	425
10	3000	720	420
10	5000	720	440

25-Cycle Turbines

Poles	Kw	R.P.M.	Bucket Speeds
2	300	1500	334
2	1000	1500	400
4	2000	750	355
4	3000	750	437
4	5000	750	460
4	8000	750	460

Direct-Current Horizontal-Shaft Turbines

Poles	Kw Capacity	Speed	Voltage
2	15	4000	80-125-250
2	20	4000	125-250
2	25	3600	125-250
4	75	2400	125-250
4	150	1800	125-250
4	300	1800	125-250-575

The total number of turbines of the Curtis type manufactured by the General Electric Company shipped or on order is 592 units, an aggregate of 580,325 kilowatts. Of these, 385 units are of 500 kilowatts or larger. We append hereto a list of the larger sizes either shipped or installed.

CURTIS TURBINES SHIPPED

Purchaser	Number of Units	Kw Capacity Each Unit
The Edison Electric Illuminating Co., Boston, Mass.	2	5000
The New York Edison Co., New York City, N. Y.	4	5000
Chicago Edison Co., Chicago, Ill.	4	5000
Metropolitan Street Railway Co., Kansas City, Mo.	1	5000
St. Louis Transit Co., St. Louis, Mo.	2	5000
New York Central & Hudson River Railroad Co.	4	5000
Union Electric Light and Power Co., St. Louis, Mo.	2	5000
North Jersey Street Railway Co., Newark, N. J.	2	5000
The Philadelphia Electric Co., Philadelphia, Pa.	1	5000
Edison Illuminating Co. of Detroit, Detroit, Mich.	4	3000
United Electric Co. of New Jersey, Newark, N. J.	1	3000
North Jersey Street Railway Co., Newark, N. J., for Jersey City	1	3000
Nashville Railway and Light Co., Nashville, Tenn.	1	3000
Birmingham Railway, Light and Power Co., Birmingham, Ala.	1	3000
Potomac Electric Power Co., Washington, D. C.	2	2000
The Edison Electric Co., Los Angeles, Calif.	2	2000
Old Colony Street Railway Co., Boston, Mass.	5	2000
Boston & Worcester Street Railway Co., Boston, Mass.	1	2000
St. Louis Transit Co., St. Louis, Mo.	2	2000
Georgia Railway and Electric Co., Atlanta, Ga.	1	2000
Canton & Akron Railway Co., Akron, Ohio	1	2000
Power Plant, Schenectady Works, Schenectady, N. Y.	1	2000
Hudson River Water Power Co., Glens Falls, N. Y.	1	2000
Central Illinois Traction System, Decatur, Ill.	1	2000
Arlington Mills, Lawrence, Mass.	1	2000
Boston Elevated Railway Co., Boston, Mass.	1	2000
Havana Central Railway Co., Havana, Cuba	2	2000
Philadelphia Rapid Transit Co., Philadelphia, Pa.	1	2000
Columbus, Delaware & Marion Railway Co., Columbus, Ohio	1	2000
West Jersey & Sea Shore Railway, Camden, N. J.	2	2000
Southeastern Construction Co., Philadelphia, Pa.	2	2000
Carnegie Steel Co., Pittsburgh, Pa.	1	2000
Port Huron Light and Power Co., Port Huron, Mich.	1	1500
St. Joseph Light, Heat and Power Co., St. Joseph, Mo.	1	1500
Syracuse Lighting Co., Syracuse, N. Y.	2	1500
Omaha Electric Light and Power Co., Omaha, Nebr.	1	1500
Houston Lighting and Power Co., Houston, Tex.	1	1500
Nassau Light and Power Co., Roslyn, N. Y.	1	1500
Indianapolis Light and Power Co., Indianapolis, Ind.	2	1500
Tokyo Street Railway Co., Japan	5	1500
Nashville Railway and Light Co., Nashville, Tenn.	1	1500
Portland General Electric Co., Portland, Ore.	2	1500
Knoxville Traction Co., Knoxville, Tenn.	2	1500
New Orleans Railways Co., New Orleans, La.	2	1500
Norfolk Railway and Light Co., Norfolk, Va.	1	1500

Purchaser	Number of Units	Kw Capacity Each Unit
Power Plant, Schenectady Works, Schenectady, N. Y.	3	1500
Little Rock Railway and Electric Co., Little Rock, Ark.	1	1500
Jackson Light and Power Co., Jackson, Mich.	1	1500
Dallas Electric Light and Power Co., Dallas, Tex.	1	1500
Minneapolis General Electric Co., Minneapolis, Minn.	1	1500
Northern Ohio Traction Co., Akron, Ohio	1	1500
Terre Haute Traction and Light Co., Terre Haute, Ind.	1	1500
Consolidated Power and Light Co., Pluma, S. D.	2	1500
Lynn Gas and Electric Co., Lynn, Mass.	1	1500
Los Angeles Gas and Electric Co., Los Angeles, Calif.	1	1500
Macon Railway and Light Co., Macon, Ga.	1	1500
Cowanshannock Coal and Coke Co., Echo, Pa.	1	1500
Decatur, Springfield & St. Louis Railway Co., Springfield, Ill.	1	1000
Milwaukee Electric Railway and Light Co., Milwaukee, Wis.	2	1000
Peoria Gas and Electric Co., Peoria, Ill.	1	1000
Public Service Corporation of New Jersey, for Metuchen, N. J.	2	1000
A. T. H., Paris, France, for Algiers	2	1000
Farr Alpaca Co., Holyoke, Mass.	1	1000
Hudson River Water Power Co., Glens Falls, N. Y.	1	1000
Consolidated Gold Fields of South Africa	1	1000
Fairmont & Clarksburg Traction Co., Va.	1	1000
Havana Central Railway Co., Havana, Cuba	1	1000
Chicago & Milwaukee Electric Railway Co., Highwood, Ill.	1	1000
New London Gas and Electric Co., Conn.	1	1000
United Shoe Machine Co., Beverly, Mass.	1	1000
C. F. T. H., Paris, France, for Nice	2	800
Toledo & Interurban Railway Co., Toledo, Ohio	1	800
East St. Louis & Suburban Railway Co., East St. Louis, Ill.	1	800
Philadelphia Rapid Transit Co., Philadelphia, Pa.	2	800
A. T. H., Paris, France, for Nancy	1	650
Fore River Ship Building Co., Fore River, Mass.	1	600
Power Plant, Schenectady Works, N. Y.	1	600
Cork Tramways, Cork, Ireland	1	500
B. T. H. Co., Rugby, England	3	500
Harrogate Corporation Electric Works, Limited, Harrogate, England	1	500
Christ Church Municipal Tramways, Christ Church, New Zealand	2	500
Pennsylvania Railroad Co., for Greenville Shops, Greenville, N. J.	2	500
Philadelphia & Westchester Traction Co., Llanerch, Pa.	1	400
C. F. T. H., Paris, for Rheims	1	500
Boston & Northern Street Railway Co., Boston, Mass.	5	500
Scranton Railway Co., Scranton, Pa.	1	500
Binghamton Light, Heat and Power Co., Binghamton, N. Y.	1	500
Macon Railway Light Co., Macon, Ga.	1	500
United Gas and Electric Co., Dover, N. H.	2	500
Newport & Fall River Street Railway Co., Newport, R. I.	3	500
Zanesville Railway, Light and Power Co., Zanesville, Ohio	2	500
Nashua Light, Heat and Power Co., Nashua, N. H.	2	500
Chattanooga Light and Power Co., Chattanooga, Tenn.	3	500
Delaware, Lackawanna & Western Railroad Co., Scranton, Pa.	7	500
LaClede Light and Power Co., St. Louis, Mo.	2	500
Richmond Light and Railway Co., Staten Island, N. Y.	2	500
Winona Railway and Light Co., Winona, Minn.	2	500

Purchaser	Number of Units	Kw Capacity Each Unit
Union Electric Co., Dubuque, Iowa	4	500
Phœnix Light and Fuel Co., Phœnix, Ariz	1	500
Lynn Gas and Electric Co., Lynn, Mass	1	500
Gloucester Electric Co., Gloucester, Mass	1	500
Westchester Lighting Co., New Rochelle, N. Y	1	500
Fulton Bag and Cotton Mills, Atlanta, Ga	2	500
United Gas and Electric Co., New Albany, Ind	2	500
U. E. G. Co., Berlin, Germany	1	500
Lane Cotton Mills, New Orleans, La	3	500
Columbus Railway and Light Co., Columbus, Ohio	2	500
Saginaw Valley Track Co., Saginaw, Mich	2	500
Consolidated Gold Fields of South Africa, Limited	4	500
Lynn Works Power Plant, Lynn, Mass	1	500
Witwaters Rand Deep Gold Mining Co., Limited, South Africa.	1	430
Yokohama Union Electric Light Co., Yokohama, Japan	2	500
Tokyo Military Arsenal, Japan	5	500
Tokyo Military Arsenal (Oji Station), Japan	2	500
Economy Light and Power Co., Joliet, Ill	1	500
Monterey Electric Light and Power Co., Monterey, Mexico	1	500
Meridian Light and Railway Co., Meridian, Miss	1	500
Terre Haute Traction and Light Co., Terre Haute, Ind	1	500
Tokyo Electric Lighting Co., Japan	2	500
Spanish-American Light and Power Co., Havana, Cuba	2	500
Edison Electric Co., Philadelphia, Pa	1	500
Beacon Light Co., Chester, Pa	1	500
John Morrell & Co., Limited, Ottumwa, Iowa	1	500
Hot Springs Water Co., Hot Springs, Ark	1	500
Victor Manufacturing Co., Greers, S. C	2	500
Muncie Plant, Jacksonville, Fla	1	500
Public Service Corporation of New Jersey, for Metuchen, N. J.	1	500
Osaka Military Arsenal, Japan	8	500
United Shoe Machinery Co., Boston, Mass	2	500
Marion Lighting and Heating Co., Marion, Ind	2	500
Oshkosh Electric Light and Power Co., Oshkosh, Wis	2	500
International Light and Power Co., El Paso, Tex	1	500
Electric Lighting Co., Mobile, Ala	1	500
Toronto Electric Light Co., Toronto, Canada	3	500
Nagoya Electric Light Co., Japan	1	500
Oji Paper Mill, Japan	1	500
Mexican Light and Power Co., Mexico	4	500
Mobile Light and Railway Co., Mobile, Ala	1	500
Easton Gas and Electric Co., Easton, Pa	2	500
City of Holyoke, Mass	1	500
Scoville Manufacturing Co., Waterbury, Conn	1	500
Canadian Pressed Steel Car Co., Montreal, Canada	1	500
Media, Middletown, Aston & Chester Railway Co., Folsom, Pa.	1	500
Power Plant, Schenectady Works, Schenectady, N. Y	1	500
Osaka Electric Light Co., Japan	4	500
Suburban Gas and Electric Co., Revere, Mass	1	500
Grand Rapids Edison Co., Grand Rapids, Mich	1	500
Waterloo & Cedar Falls Electric Light and Power Co., Cedar Falls, Iowa	1	500
Lawrence Gas Co., Lawrence, Mass	2	500
Attleboro Steam and Electric Co., Attleboro, Mass	1	500
Evanston Heating and Lighting Co., Evanston, Ill	1	500

Purchaser	Number of Units	Kw Capacity Each Unit
Wilkesbarre Gas and Electric Co., Wilkesbarre, Pa	1	500
Nashua Manufacturing Co., Nashua, N. H	1	500
Portland Railroad Co., Portland, Me	2	500
North Shore Electric Co., Maywood, Ind	1	500
Siam Electric Co., Bangkok, Siam	1	500
Consolidated Power and Light Co., Pluma, S. D	1	500
Evansville Gas and Electric Co., Ind	1	500
Fairmont & Clarksburg Traction Co., Va	2	500
Holyoke Water Power Co., Mass	1	500
Jackson Electric Railway and Power Co., Miss	1	500
Coe Brass Co., Ansonia, Conn	1	500
City of Wellington, New Zealand	1	500
Lehigh Valley Traction Co	1	500
Delaware & Hudson Co., Iron Mountain, N. Y	1	500
San Diego Gas and Electric Co., Calif	1	500
Empresa Electric Co. of Santa Rosa, Calloa, Peru, South America	1	500
City Corporation of Winnipeg, Canada	1	500
Queensboro Gas and Electric Co., Far Rockaway, N. Y	1	500
City Electric Railway Co., Rome, Ga	1	500
Kansas Natural Gas Co., Glen Flora, Tex	1	500
Publishers' Paper Co., Portsmouth, N. H	2	500
Guinle & Co., Rio de Janeiro, South America	1	500
Rockingham County Light and Power Co., Portsmouth, N. H.	1	500

MANUFACTURERS OF THE WESTINGHOUSE-PARSONS TURBINE

The committee visited the works of the Westinghouse Machine Company, Pittsburgh, on Friday, April 6, and discussed with Messrs. Sniffin and West the various changes and the progress made in their steam turbine during the past year.

Mr. Sniffin reports that during the past year they have had very successful results from their turbines and he has sent letters to all of the users of their turbines requesting information concerning their operation; the details of these he stated he would be glad to place at the disposal of the committee. Copies of these letters were sent to the committee, and examination shows that practically very little trouble has developed in the regular operation of the turbines. The Westinghouse company now has in operation 144 units, or a capacity of 122,270 kilowatts. It has shipped or on order 130 units, equivalent in capacity to 200,250 kilowatts, making a total number of 274 units, an equivalent capacity of 322,520 kilowatts. The turbines this company has sold up to April 14, 1906, are as follows:

LIST OF WESTINGHOUSE STEAM TURBINE UNITS SOLD TO APRIL 14, 1906

In Operation

Name of Customer	Size and Number of Units No.	Kw
Athens Electric Co., Athens, Ga.	1	500
Atlantic Mills, Providence, R. I.	1	400
Baltimore Copper Smelting and Rolling Co., Baltimore, Md.	1	1200
Baltimore Electric Power Co., Baltimore, Md.	3	2000
Belleville Portland Cement Co., Belleville, Ontario, Canada	1	400
Jos. Benn & Sons, Providence, R. I.	1	400
Black Mountain Mining Co. (Cerro Prieto Gold Mines), Sonora, Mexico	2	500
Boston & Maine Railroad Co., Boston, Mass.	2	500
Brown Manufacturing Co., Concord, N. C.	1	300
California Powder Works, Pinole, Calif.	1	400
Canadian Klondike Mining Co., Ltd., Dawson City, Alaska	1	400
Canadian Pacific Railway Co., Ft. William, Ontario, Canada	1	500
Citizens' Light, Heat and Power Co., Johnstown, Pa.	2	400
City of Anderson, Anderson, Ind.	2	400
City of Columbus, Columbus, Ohio	3	400
City of Moorhead, Moorhead, Minn.	1	300
Cleveland & Southwestern Traction Co., Elyria, Ohio	2	1000
Cleveland Frog and Crossing Co., Cleveland, Ohio	1	500
Columbus Public Service Corporation, Columbus, Ohio	1	1000
Consolidated Railways, Light and Power Co., Wilmington, N.C.	2	400
Cornell University, Ithaca, N. Y.	1	150
De Beers Consolidated Mines, Ltd., Kimberley, South Africa	2	1000
	1	1500
Eaton, Cole & Burnham, Bridgeport, Conn.	2	400
Everett Railway, Light and Water Co., Everett, Wash.	1	750
The Robert C. Fisher Co., New York, N. Y.	1	400
Ft. Wayne & Wabash Valley Traction Co., Ft. Wayne, Ind.	1	500
B. F. Goodrich Co., Akron, Ohio	1	400
	1	750
Gray Manufacturing Co., Gastonia, N. C.	1	300
Grays' Harbor Electric Co., Aberdeen, Wash.	1	400
Great Falls & Old Dominion Railway Co., Rosslyn, Va.	1	750
The Hampton Co., Hampton, Mass.	1	400
Hartford Electric Light Co., Hartford, Conn.	2	750
	1	1500
	1	2000
Haverhill Electric Co., Haverhill, Mass.	2	1000
Henrietta Mills, Henrietta, N. C.	1	400
Home Lighting, Power and Heating Co., Springfield, Ohio	1	500
Hot Springs Electric Co., Hot Springs, Ark.	1	400
Iowa & Illinois Railway Co., Clinton, Iowa	2	400
Interborough Rapid Transit Co., New York, N. Y.	3	1250
	1	5500
Johnston Harvester Co., Batavia, N. Y.	1	400
Lake Charles Ice, Light and Water Works, Lake Charles, La.	1	400
Lewiston Water and Power Co., Lewiston, Idaho	1	500
Madison Gas and Electric Co., Madison, Wis.	1	400
Manila Electric Railroad and Light Co., Manila, P. I.	3	750
	1	1500
Merchants' Heat and Light Co., Indianapolis, Ind.	2	750
Missoula Light and Water Co., Bonner, Mont.	1	500

Name of Customer	Size and Number of Units No.	Kw
Modena Cotton Mills, Gastonia, N. C.	1	300
Nassau Light and Power Co., Roslyn, L. I., N. Y.	2	400
Newhouse Mines and Smelter Co. (Cactus Mine), near Frisco, Utah	2	400
New York, New Haven & Hartford R. R. Co., Warren, R. I.	2	750
New York & Queens Electric Light and Power Co., Astoria, L. I., N. Y.	1	1500
Northern Electric and Manufacturing Co., Montreal, Quebec	1	300
Oneida Knitting Mills, Utica, N. Y.	1	500
Ottawa Electric Co., Ottawa, Canada	1	1500
Parkersburg, Marietta & Interurban Railway, Parkersburg, W. Va.	1	400
Pelzer Manufacturing Co., Pelzer, S. C.	1	1500
Pennsylvania, New York & Long Island R. R., Long Island City, N. Y.	3	5500
Pennsylvania Railroad Co., Trenton, N. J.	1	500
Pennsylvania Light, Heat and Power Co., Allegheny, Pa.	2	500
Philadelphia Rapid Transit Co., Philadelphia, Pa.	6	1500
Philadelphia Rubber Co., Philadelphia, Pa.	1	400
Portsmouth Street Railway and Light Co., Portsmouth, Ohio.	2	400
Pressed Steel Car Co., McKees Rocks, Pa.	1	500
Public Service Corporation of New Jersey, Trenton, N. J.	1	500
Rhode Island Co., Providence, R. I.	1	2500
Rockland Light and Power Co., Nyack, N. Y.	2	400
Rome Metal Co., Rome, N. Y.	1	400
Saco & Pettee Machine Shops, Biddeford, Me.	2	400
Savannah Electric Co., Savannah, Ga.	1	500
Shamokin & Coal Township Light and Power Co., Shamokin, Pa.	1	400
Sherwin-Williams Co., Cleveland, Ohio	1	400
Tokyo Electric Light Co., Tokyo, Japan	4	1000
Toledo Heating and Lighting Co., Toledo, Ohio	2	1000
Union Metallic Cartridge Co., Bridgeport, Conn.	2	400
The Indian Orchard Co., Indian Orchard, Mass.	1	1000
United Electric Light Co., Springfield, Mass.	3	1000
United States Navy Yard, Boston, Mass.	1	750
S. D. Warren & Co., Cumberland Mills, Me.	3	400
Westinghouse Air Brake Co., Wilmerding, Pa.	4	400
Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.	2	750
West Penn Railways and Lighting Co., Connellsville, Pa.	3	1000
Wisconsin Light and Power Co., La Crosse, Wis.	2	400
West Virginia Pulp and Paper Co., Piedmont, W. Va.	2	1000
Yale & Towne Manufacturing Co., Stamford, Conn.	2	400
Northern Heating and Electric Co., St. Paul, Minn.	1	300
Suburban Electric Co., Scranton, Pa.	1	500

Shipped, Erected or in Process of Erection

Beacon Manufacturing Co., New Bedford, Mass.	1	500
Bisbee Improvement Co., Bisbee, Ariz.	1	300
Calumet & Arizona Mining Co., Bisbee, Ariz.	1	300
City of Detroit, Detroit, Mich.	1	2000
Edison Electric Illuminating Co., Brooklyn, N. Y.	1	7500
Gulfport & Mississippi Coast Traction Co., Gulfport, Miss.	2	500
Helena Power Transmission Co., Helena, Mont.	2	2000

Name of Customer	Size and Number of Units No.	Kw
Lumberton Cotton Mills, Lumberton, N. C.	1	300
New York Edison Co., New York, N. Y.	1	7500
Pennsylvania, New York & Long Island R. R., Long Island City, N. Y.	1	200
Rochester, Syracuse & Eastern R. R., Syracuse, N. Y.	2	1500
Quincy Market Cold Storage and Warehouse Co., Quincy, Mass.	1	500
Solvay Process Co., Syracuse, N. Y.	1	500
Transit Development Co., Brooklyn, N. Y.	2	7500
Utica Steam & Mohawk Valley Cotton Mills, Utica, N. Y.	1	1000
	1	300
Waltham Gas Light Co., Waltham, Mass.	2	500
The Westinghouse Machine Co., East Pittsburgh, Pa.	1	500
Winston-Salem Power Co., Winston-Salem, N. C.	1	750
Baltimore & Ohio Railroad Co., Lorain, Ohio	1	300
E. R. Ladew, Glen Cove, L. I., N. Y.	1	300
Pennsylvania Light, Heat and Power Co., Allegheny, Pa.	1	500
North Mountain Power Co., Eureka, Calif.	1	500
Western Steel Car and Foundry Co., Hegewisch, Ill.	2	500
City of Toronto, Toronto, Canada	2	750
Oliver Iron and Steel Co., Pittsburgh, Pa.	1	1000
Wilkesbarre & Hazleton Railway Co., Hazleton, Pa.	2	1000

Building and on Order

Name of Customer	No.	Kw
Allegheny County Light Co., Pittsburgh, Pa.	1	1000
Cincinnati Northern Traction Co., Hamilton, Ohio	1	500
	3	1500
The Edison Electric Co., Los Angeles, Calif.	1	7500
Ft. Wayne & Wabash Valley Traction Co., Ft. Wayne, Ind.	1	400
	4	1500
The New York Edison Co., New York, N. Y.	1	7500
Pennsylvania, New York & Long Island R. R., Long Island City, N. Y.	1	200
Philadelphia Rapid Transit Co., Philadelphia, Pa.	3	6000
Portsmouth Street Railway and Light Co., Portsmouth, Ohio	1	500
Public Service Corporation of New Jersey, Camden, N. J.	3	1000
Public Service Corporation of New Jersey, Cranford, N. J.	1	500
The Westinghouse Machine Co., East Pittsburgh, Pa.	2	500
San Diego Electric Railway, San Diego, Calif.	1	1000
Transit Development Co., Brooklyn, N. Y.	2	7500
Washington Terminal Co. (P. R. R. Co.), Washington, D. C.	4	500
Water, Light and Gas Co., Hutchinson, Kan.	1	500
Chautauqua Traction Co., Jamestown, N. Y.	1	1500
Citizens' Heat and Power Co., Adrian, Mich.	1	500
Columbia Electric Street Railway, Light and Power Co., Columbia, S. C.	2	1500
Detroit United Railway Co., Detroit, Mich.	1	1000
E. I. DuPont Co., Wilmington, Del.	1	300
Griffin Wheel Co., Pullman, Ill.	1	300
	2	500
Kennebec Light and Heat Co., Augusta, Me.	1	500
Lake Shore Electric Railway Co., Beach Park, Ohio	1	2000
Laclede Power Co., St. Louis, Mo.	2	2000
Mount Whitney Power Co., Visalia, Calif.	1	1000
Louisville Lighting Co., Louisville, Ky.	1	3000
New York, New Haven & Hartford R. R. Co., New Haven, Conn.	3	3000

Name of Customer	Size and Number of Units No.	Kw
Durham Traction Co., Durham, N. C.	1	500
North Shore Electric Co., San Francisco, Calif.	1	1000
Phosphate Mining Co., Lakeland, Fla.	2	500
Pittsburgh & Butler Railway, Pittsburgh, Pa.	2	750
South Park Commissioners, Chicago, Ill.	1	1000
Tide Water Oil Co., Bayonne, N. J.	1	500
United Electric Light and Power Co., Georgetown, Colo.	1	500
United Electric Light and Power Co., New York, N. Y.	2	7500
St. Paul Gas Light Co., St. Paul, Minn.	1	1500
Washington, Alex. & Mt. Vernon Ry. Co., Washington, D. C.	1	1000
Washburn-Crosby Co., Minneapolis, Minn.	1	300
West Virginia Pulp and Paper Co., Covington, Va.	1	1000
Merchants' Heat and Light Co., Indianapolis, Ind.	1	750
Los Angeles Pacific Railway Co., Los Angeles, Calif.	1	2750
The Toledo Gas, Electric and Heating Co., Toledo, Ohio.	1	3000
Wheeling Electric Co., Wheeling, W. Va.	1	500
Green Bay Gas and Electric Co., Green Bay, Wis.	1	500
Grand Trunk Railway (St. Clair Tunnel), St. Clair, Mich.	2	1500
Atlantic Coast Line, Waycross, Ga.	2	300
Northern Heating and Electric Co., St. Paul, Minn.	1	1000
Delaware, Lackawanna & Western R. R., Hoboken, N. J.	2	500
Oak Park Construction Co., Oak Park, Ill.	1	500
American Rio Grande Land and Irrigation Co., Lonsboro, Tex.	2	300
Detroit, Monroe & Toledo Street Railway, Detroit, Mich.	1	1200
City of Burlington, Burlington, Vt.	1	300
Tampa Electric Co., Tampa, Fla.	1	1000
Rosemary Manufacturing Co., Roanoke Rapids, N. C.	1	500
The Denver Gas and Electric Co., Denver, Colo.	1	1000
Delmarvia Construction Co., Wilmington, Del.	2	500
West Side Power, Heat and Light Co., St. Paul, Minn.	2	300
Shawnee Lighting Co., Shawnee, Okla.	1	500
Union Portland Cement Co., Portland, Utah.	2	1200
Francis Cotton Mills, Biscoe, N. C.	1	300
Sheffield Co., Sheffield, Ala.	1	1000
United States Navy Yard, New York, N. Y.	2	500

The changes in the design since our last report consist particularly in the type of lacing used in the blading. The lacing used and described in our last report consists of flat steel lacing twisted between each blade. The lacing now in use in cross-section is similar to the "apostrophe" and the thin edge is bent over between each blade insuring uniform spacing and a tighter joint than was possible with the flat lacing twisted. This makes a more rigid construction and is easier applied. The lacing is not continuous, but cut in sections so as to allow the lace freedom to expand without interfering with the spacing between the blades. The extra lacing which was introduced at the joints has been abandoned. It is claimed that where the blades touch the casing of the turbines the cast-iron casing had been cut and the blading had not been destroyed.

A rotary pump has been substituted for the plunger type supplying oil to the bearings.

The most noticeable feature in inspecting the shop was the number of large turbines now being built, and the appearance of the shop indicated that steam turbines were very decidedly the largest percentage of the output of the shop.

The double-flow turbines that were experimented with during our previous visit have been very materially changed in both design and construction. We were fortunate in being able to examine the construction of one of these experimental machines. The first stage consists of an impulse wheel with two sets of buckets, steam being admitted through three nozzles, two arranged at the top and one at the bottom of the casing. The steam after leaving the impulse wheel passes on to a series of Parsons blading. After passing through a second stage, assuming that the impulse wheel is the first stage, the steam is divided, continuing in the same direction through the blading, the balance being carried through openings in the cylinder to which the blades are attached to the opposite end to another set of Parsons blading and in this way balancing the thrust.

We saw one of these machines in regular operation in the works of the Westinghouse Electric and Manufacturing Company, apparently giving satisfactory results. The advantages claimed for this machine are that it obviates the necessity of the use of large balancing pistons and it materially shortens the length and reduces the diameter, making the machine more compact; for these reasons the design particularly lends itself to the larger sizes. Sufficient information has not been obtained to know whether the economy will be as good or better as compared to the standard Westinghouse-Parsons type. Efforts are being made to push forward the completion of the experimental machine so as to obtain necessary data on all of the details. It is not expected, however, that this machine will supersede the machines that are now being manufactured, but in all probability it will be more suitable for certain sizes.

MANUFACTURERS OF THE ALLIS-CHALMERS TURBINE

The committee visited the works of the Allis-Chalmers Company, in Milwaukee, Wis., Saturday, April 7, and was received by Messrs. Doran and Rotter, and later met the engineers connected with various departments of the turbines designed by the Company. The first visit was to the works of the company at West Allis. We were taken through the various departments, starting with the pattern shop and ending in the erecting shop, and we were impressed with the activity and progress that were everywhere present. We found extensive additions were being made to its plant. In the engine shop a 1500-kw turbine had been opened up for our inspection. The principal difference between this type of turbine and the Parsons turbine is in the mechanical construction, balancing pistons, blading, the governing device, and some other details given in the appended manufacturer's description, which we are giving at some length as it is the first time this machine has, we believe, been described by the committee.

The workmanship of all of the parts of this machine is excellent, and the uniformity of spacing between the blades, the height of each blade and the gauging are most accurately maintained.

The casing has been designed with great care to maintain the spacing, and to allow for proportionate expansion due to various changes in temperature to which it may be subjected.

After a very careful examination of all parts of this machine the committee visited the Reliance works in Milwaukee, where the blading work is done. Although at the time of our visit these works were closed, it being Saturday afternoon, the various machines were started and the entire operation shown to us.

Previous to our visit to the works we had examined an Allis-Chalmers turbine at Utica. This turbine had not been in operation for three weeks, and, although cold, was started and full load put on it in less than ten minutes. The load was afterward increased to 50-per cent overload, and the operation was apparently very satisfactory.

The manufacturer's description of the Allis-Chalmers turbine is as follows:

TURBINE

This turbine is of the Parsons type with improvements in detail of construction, and is the result of practical experience and systematic experiments extending over a period from 1884 up to the present time.

This company has entered into an arrangement with the Hon. Chas. Parsons whereby it has the benefit of all his experience, together with rights of his latest improvements. It has also secured the rights of the Fulleger and Sankey patents for blading.

Cylinder

The cylinder or casing, in which are secured the stationary

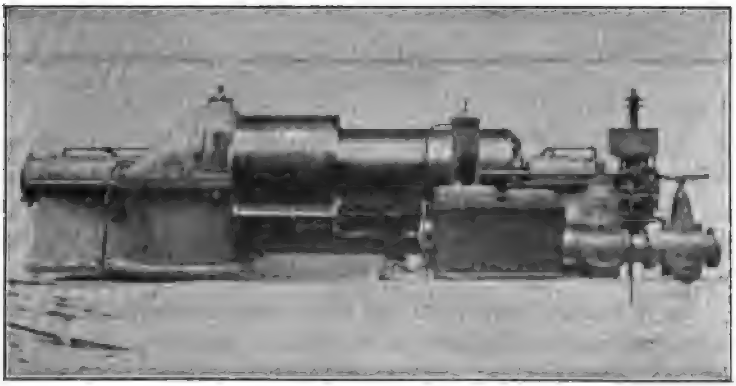


FIG. 5—ALLIS-CHALMERS TURBINE

or guide blades, is made of a selected grade of cast iron and is divided horizontally to give ready access to the internal parts.

Although a cylinder may easily be constructed so that it leaves the shop absolutely true in all its parts, yet the necessity of insuring the retention of its correct form within a very fine degree under varying conditions of temperature demands the closest attention to details in design and construction.

The cylinders are so proportioned as to prevent deformation due to temperature variations when in operation. In order to more thoroughly eliminate internal strains, the cylinders of all except the smaller turbines, instead of following the older method of having the top and bottom parts each made in one casting, are

divided into two or more sections in their length, and the castings of the cylinder proper are made separate from those containing the bearings. These sections are finally permanently bolted together so that no joints, except the horizontal ones, need be disturbed in overhauling.

All castings after the removal of the skin by machining are in a state of strain, and, as the result of repeated heatings and coolings, are apt to change their shape to a small extent, such changes being greater during the first few variations of temperature than subsequently. In order to eliminate this objection as far as possible, the sections of the Allis-Chalmers turbine, after rough machining, are "seasoned" by being subjected several times to high steam temperature with alternate coolings, and it is only after this seasoning process that the castings are finally machined to finished size.

Spindle or Rotor

The spindle is made of high-grade steel, with accurately machined and highly polished journals. The details of construction vary with the size of the turbine, being in each case designed to give the necessary strength and stiffness, combined with minimum weight in order to reduce the load on the bearings.

In the larger diameters the rings that carry the blades are made separate from the body of the spindle, as also are the balance pistons. These parts are provided with tapered fits and are assembled by pressing, no shrink fits being used. Each of the separate parts is carefully balanced before assembling. After the final assembling the complete spindle (Figure 6) is carefully and accurately balanced so as to prevent even the slightest vibration when running.

The arrangement of balancing piston in the larger sizes is one of the special features of the design. The large low-pressure piston is omitted and a smaller piston substituted at the opposite end, receiving steam at a higher pressure as shown diagrammatically in Figure 7.

In this design the large balance piston has been replaced by the smaller piston, *Z*, at the low-pressure end of the turbine; this latter balance piston working inside the supplementary cylinder, *W*.

In this construction the equalizing pipe is omitted, the pressure on the balance piston at *Y* being equalized with that on

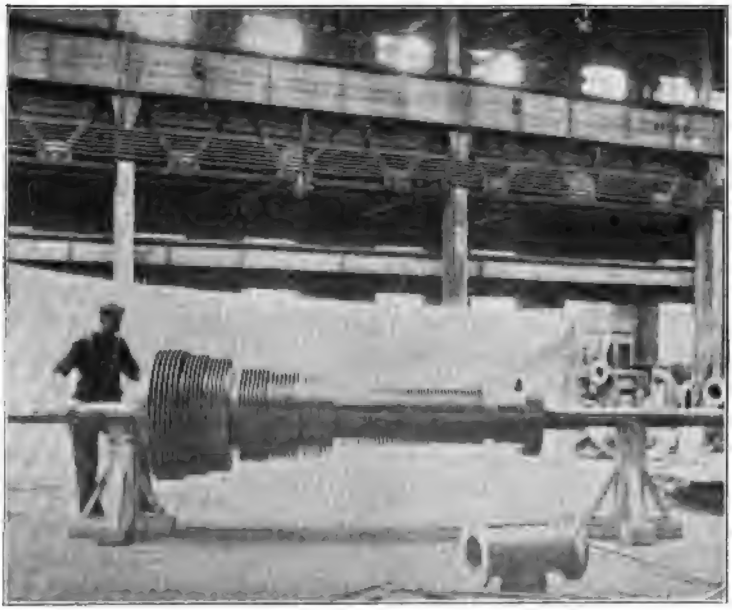


FIG. 6—SPINDLE OF ALLIS-CHALMERS TURBINE

the third stage of the blading at *X* by means of passages (not shown) through the body of the spindle. This piston, *Z*, is not

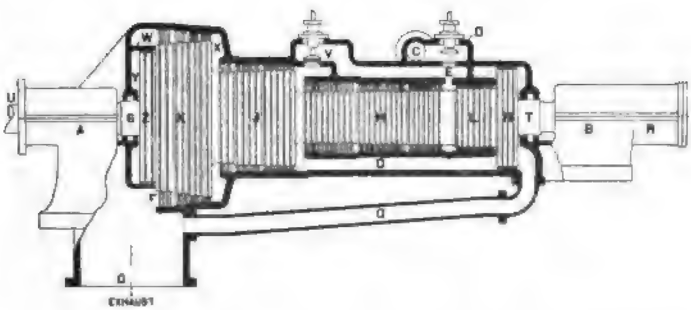


FIG. 7—ELEMENTARY PARSONS TURBINE WITH ALLIS-CHALMERS MODIFICATIONS

only much smaller than the equivalent piston, but it is immensely stiffer, being backed up by the body of the spindle.

As, due to varying temperatures, there is an appreciable difference in the endwise expansion of the spindle and cylinder, the baffling-rings in the new construction of low-pressure balance piston are so made as to allow for this difference. The high-pressure end of the spindle being held by the thrust-bearing, the difference in expansion manifests itself at the low-pressure end. The labyrinth packing of the high-pressure and intermediate pistons has a small axial and ample radial clearance, the same as in the older construction; whereas the labyrinth packing of this new piston at the low-pressure end has a small radial and ample axial clearance.

The elimination of the causes of trouble with the low-pressure balance piston permits of smaller working clearance in the high-pressure and intermediate pistons, with resulting improvement in steam economy.

The Allis-Chalmers method of blading differs from the older method, briefly, as follows: Each blade is individually formed by special machine tools so that at its root it is of angular dovetail shape, while at its tip there is a projection.

To hold the roots of the blades firmly there is provided a foundation ring, *A* in Figure 8, which, after being formed to a circle of the proper diameter, has slots cut in it by a special milling machine; these slots being formed of dovetail shape to receive the roots of the blades, and at the same time being accurately spaced and inclined to give the required pitch and angle to the blades.

To protect and bind together the tips of the blades in a substantial manner a shroud ring, *B*, Figure 8, is used. Holes are punched in the ring to receive the projections on the tips of the blades, these holes being accurately spaced by special machinery to match the slots in the foundation ring.

The foundation rings themselves are of dovetail shape in cross-section and are inserted in dovetailed grooves in the turbine cylinder and spindle, respectively, in which they are firmly held by key pieces. The latter, after being driven into place, are upset into undercut grooves, thereby positively locking the whole structure together and making it impossible for a blade to get out of place. Attention is especially called to the fact that each blade is firmly locked by the dovetail shape of the root, which is held between the corresponding dovetailed slot in the foundation ring,

and the undercut side of the groove. There is no friction hold or gripping action of caulking pieces as in the older method.

Figure 8, showing the assembling blading, was photographed from a drawing of medium-sized blades, the cut being of full size, with the clearance over the shroud ring exactly as actually allowed in the turbine. This illustration indicates the method of keying the blades and their foundation ring in place, and shows

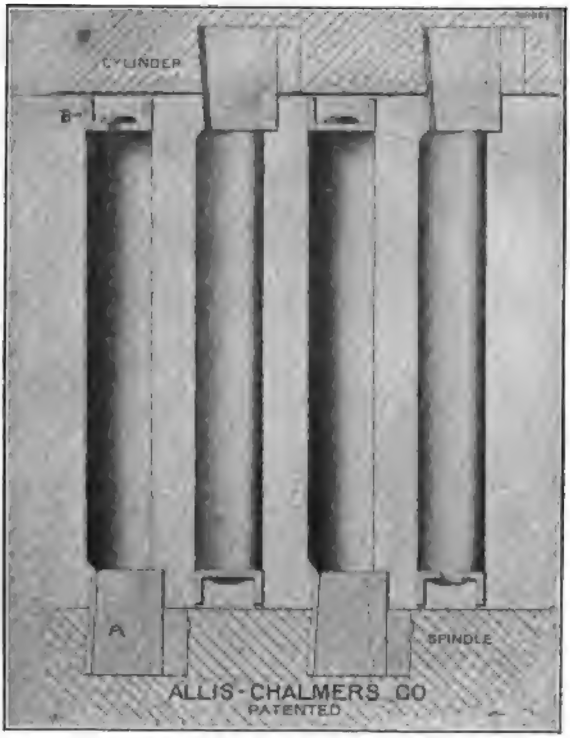


FIG. 8—DETAIL OF ALLIS-CHALMERS BLADING

the channel-shaped shroud rings fastened to the tips of the blades by riveting over the projections that were formed on the latter, thus binding the blades firmly together and stiffening them against the effect of vibration in a very much more substantial manner than possible with the older method. This construction is applied by Allis-Chalmers Company to practically all blades, however

short, whereas it has been customary with the older method to stiffen only the longer blades.

The flanges of the channel-shaped shroud rings are made thin, so that in case of contact from any accidental cause no dangerous heating will take place, nor will the rubbing rip out the blades as it does with the naked blade tips of the older construction. It has been proven, both in actual practice and experimentally, that the only effect of accidental rubbing of the shroud ring is a slight wear of the edges of its flanges.

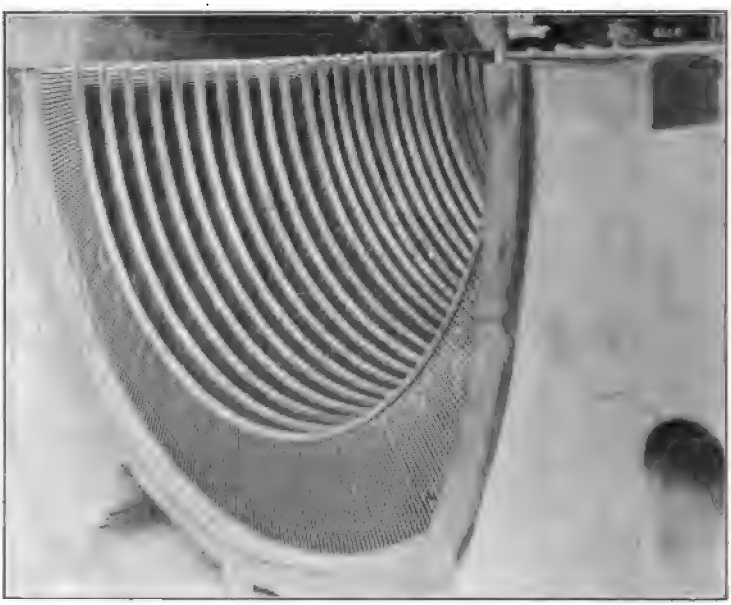


FIG. 9—STATIONARY BLADES—ALLIS-CHALMERS TURBINE

Figure 9, photographed from blading as fitted in a turbine, illustrates the substantial construction, besides showing the absolutely uniform spacing and angles of the blades. An incidental advantage of the construction is that if a blade should have any hidden defect which would escape detection by the inspector, it is so held in place by the shroud ring that it can not work loose and cause damage.

The protection afforded by the shroud ring, preventing dam-

age in case of an accidental contact of revolving and stationary parts, permits the use of smaller working clearances than are possible with naked blade tips, thereby reducing the leakage loss to a minimum. Leakage of steam is further retarded by the shape of the shroud ring, which forms a most effective baffle.

Proper provision is made for the carrying off of the water of condensation from the spaces between the adjacent stationary rows of blades, thus preventing the accumulation of such water in which the shroud rings would otherwise be forced to rotate. These provisions are made in such wise that they do not increase the steam leakage.

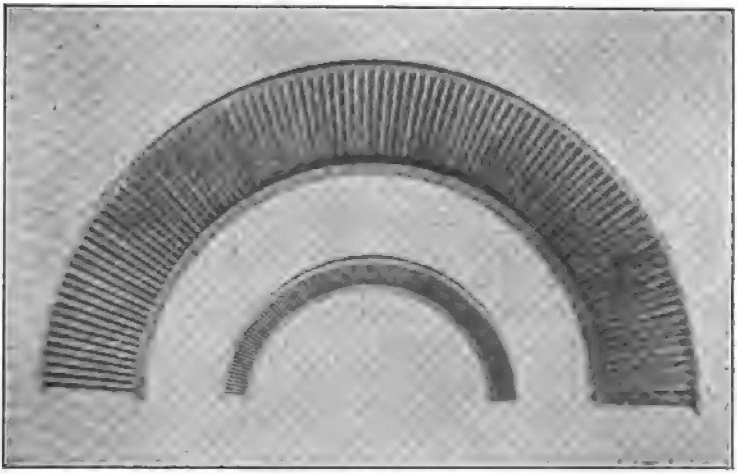


FIG. 10—ASSEMBLY OF BLADING—ALLIS-CHALMERS TURBINE

In the blading shop the blading is made up complete in half rings, ready for insertion in the turbine, the rings being carefully inspected before being sent to the turbine shop, besides being inspected and having the correctness of the workmanship confirmed by gauges during the various steps of the manufacture. The half rings of blades are illustrated in Figure 10, which shows a half ring of the smaller blades and one of the larger blades for a turbine of moderate size.

Figure 9 shows a number of rows of blading inserted in the steam turbine cylinder and indicates the mechanical accuracy of

this work, the cut having been made from an actual photograph of a commercially-built machine.

The Allis-Chalmers Company has also taken advantage of the past experience in turbine construction in selecting the material for blades, which are made of special alloys that have been found best suited to the purpose; particular attention being paid to the material of the blades that are subjected to the high temperature of superheated steam. Before being worked up into blades, the material is carefully inspected, both physically and chemically, and its ability to withstand long and continuous vibration is proven in a special testing machine.

The claims made for this method of blading are as follows:

(1) Firm attachment of blades,
(2) Accurate spacing and angles of blades,
(3) Ample stiffening of blades of all lengths against the effects of vibration,
(4) Protection of blade tips so that accidental contact does not rip out blades,
(5) Smaller clearances, resulting in diminished steam leakage,
(6) Improved baffling against steam leakage by reason of the shape of the shroud ring,
(7) Protection against a possibly defective blade coming out and destroying other blades,
(8) Accurate machine work as against uncertain hand work,
(9) The possibility of thorough inspection of workmanship.

Bearing

The bearings are of the self-adjusting, ball-and-socket pattern, especially designed for high speed, with as large bearing areas as have been demonstrated by experience to be ample for this purpose. Shims are provided for proper alignment, but are so arranged that they can not easily be tampered with. In the small and higher-speed turbines the bearing shells are made of special bronze and are carried within several concentric shells, with intermediate oil films to absorb any vibration resulting from possible slight inaccuracies of balance—a system invented and used for many years by Mr. Parsons.

In the larger and slower-speed turbines the bearing surfaces are made of a superior quality of white metal, which is

manufactured by the Allis-Chalmers Company in its own works to insure the right mixture of the right materials.

Lubrication

The lubrication of the four bearings, two for the turbine and two for the generator, is effected by supplying an abundance of oil to the middle of each bearing and allowing it to flow out at the ends. The oil is passed through a tubular cooler with water circulation, and pumped back to the bearings. The boiler feed water may be used for this purpose before going to the feed-water heater, thus utilizing the heat which would otherwise be wasted.

The oil is circulated by a pump operated by the turbine, except that where the power-house is provided with a central oiling system the pump may be omitted and oil taken from the station supply tank. Particular attention is called to the fact that it is not necessary to supply the bearings with oil pressure, but only at a head sufficient to enable it to run to and through the bearings; this head never exceeding a few feet.

With each turbine a separate pump is furnished for circulating oil for starting up, the pump being worked by hand, except in the case of large turbines, for which a steam pump is furnished.

Governor

The speed of the turbine is regulated by a governor driven from the turbine shaft by means of cut gears working in an oil bath. The governor operates a balanced throttle valve by means of a relay, except in very small sizes in which the valve is worked direct. The governing mechanism is so proportioned as to respond quickly to variations of load, but at the same time the sensitiveness is kept within such bounds as to secure the best results in the parallel operation of alternators. The governor can be adjusted for speed while the turbine is in operation, thereby facilitating the synchronizing of alternators and dividing the load as may be desired.

Safety Stop

In order to provide against any possible accidental derangement of the main governing mechanism, an entirely separate safety or overspeed governor is furnished. This governor is

driven directly by the turbine shaft without the intervention of gearing and is so arranged and adjusted that if the turbine should reach a predetermined speed above that for which the main governor is set, the safety governor will come into action and trip a valve, shutting off the steam and stopping the turbine.

Overload Valve

If a turbine were designed to take care of all possible overloads when taking steam through the first row of blades, such turbine would be unnecessarily large for ordinary loads, and at its normal or rated capacity would be so underloaded that it would not be working at its best steam economy.

The Allis-Chalmers standard turbines are therefore designed to give their maximum economy at or near the rated load, with only enough overload capacity, under normal operation, to allow for ordinary small fluctuations of load and to permit of good speed regulation. To provide for such overloads as will sometimes occur, an overload or by-pass valve is provided, to admit steam at a later stage in the turbine where the blades are larger than at the beginning, thus enabling the turbine to develop greater power at a slight sacrifice of efficiency. This valve is operated by the main governor and comes into operation only when the load attains a higher point than can be attained by the turbine when operating normally.

Steam Strainer

It is no unusual thing for careless workmen to leave in steam pipes and valves such articles as bolts, nuts, pieces of gaskets, tools, and so forth. Should these find their way into a steam turbine they would damage the blading, perhaps seriously. To guard against such contingency, each Allis-Chalmers turbine is provided with a steam strainer, with perforations large enough not to obstruct the flow of steam, yet small enough to prevent the passage of anything of such size as would damage the turbine blades.

Thrust Bearing

Although termed a "thrust bearing," this element has practically no thrust to carry. Its principal function is to locate the

turbine spindle accurately in an axial direction, as previously explained. For this reason it is made adjustable, but the wearing surfaces are so large that, when once set, it should not need readjustment, even after years of operation. Like the main bearings, it is automatically lubricated by a flood of oil. In order to prevent tampering with the setting, means are provided whereby a change of adjustment is made difficult, and the adjusting mechanism can be locked up if desired.

Coupling

For connecting the rotors of the turbine and generator a special type of flexible coupling is used to provide for any slight inequality in the wear of the bearings, to permit axial adjustment of the turbine spindle and to allow for differences in expansion. This coupling is so made that it can be readily disconnected for the removal of the turbine spindle or of the revolving field of the generator. Provision is made for the ample lubrication of the adjoining faces of the coupling. The coupling is enclosed in the bearing housing, so that it is completely protected against damage, and can not cause injury to the attendants.

Lagging

The hot parts of the turbine up to the exhaust chamber are covered with an ample thickness of non-conducting material and lagged with planished steel, giving a neat and finished appearance. The lagging is so applied that it may be easily removed, and the non-conducting covering is removable at the cylinder joint to facilitate the opening of the turbine for examination.

Bed-Plate

For large Allis-Chalmers turbines the bed-plates are divided into two parts, one carrying the low-pressure end of the turbine and the bearings of the generator, the other carrying the high-pressure end of the turbine. The turbine is secured to the former, while the latter is provided with guides which permit the machine to slide back and forth with differences of expansion caused by varying temperature, at the same time maintaining the alignment. This arrangement permits of the utilization of the entire space between the foundation piers and below the turbine for the condensing apparatus.

For small sizes of turbines, however, a single continuous bed-plate is used, so that the turbine may be shipped as a complete unit and the work of erection simplified, permitting of starting up the turbine as soon as the steam and exhaust connections can be made.

Generator

The generators, which are directly coupled with the turbine, have been carefully designed to meet the special conditions of turbine operation, and are of the revolving-field type.

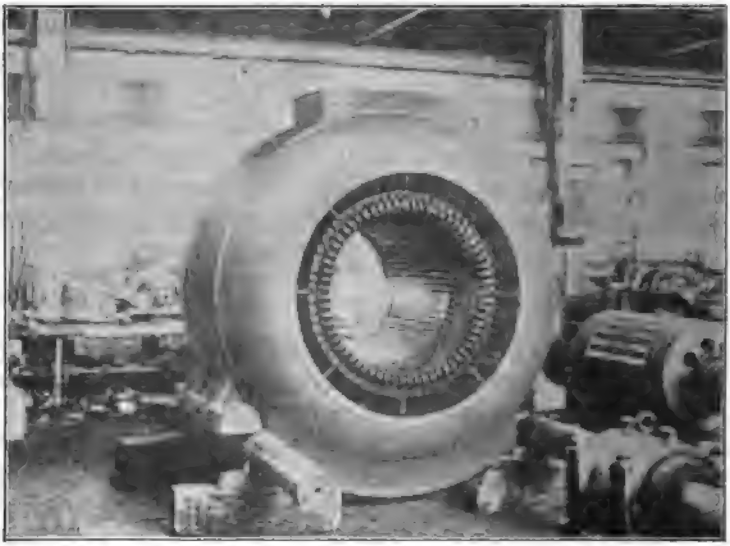


FIG. 11—STATIONARY ARMATURE OF ALLIS-CHALMERS TURBINE

The generators have been designed to give high efficiency, combined with simplicity and compactness, and especial attention has been paid to the selection of material and construction that will insure absolutely safe operation at high speeds.

Stationary Armature

In designing the stationary armature of the turbo-alternators, every precaution has been taken to secure thorough ventilation to prevent heating of the armature core and winding. The lami-

nated core, made of the best procurable electrical steel, thoroughly annealed and painted, is provided with numerous air ducts, and the cast-iron frame is so formed as to assist in the circulation of air.

The armature coils are all completely formed in the shop, so that no connections have to be made after the coils are placed in the armature core at the purchaser's station except the connections of the coil terminals, thus reducing to a minimum the risk of defective insulation at joints. The advantage of this will be appreciated by station operators, especially for high-voltage work.

The greatest care is taken in the insulation of the coils by successive dippings and bakings after the applications of the various layers of insulation. The coils are firmly secured in the slots, and particular attention has been paid to the form of the coil ends and the securing of the same in such a way as to prevent deformation in case of a short-circuit.

Revolving Field

The field cores of the Allis-Chalmers Company's turbo-generators are, according to size and conditions, built up either of steel laminations or of forged nickel-steel discs, of high magnetic permeability and great physical strength.

The slots formed in the core to receive the field coils are radial, a distinct improvement over other constructions in which, to reduce the cost of manufacture, the slots are made parallel to chords of the cross-section of the core. That this older form of construction results in complex stresses due to centrifugal force can readily be seen, and its weakness has been proven in practice; moreover, the field coils themselves are subjected to indirect instead of only radial forces, thereby making it difficult to procure an insulation that will not soon be injured by the centrifugal force.

The Allis-Chalmers method of winding the field with flat strap copper in radial slots has been made possible by the use of a specially designed forming machine which winds the copper on edge and gives an increasing spread to each successive turn of the coil. The carefully insulated coils are placed in the slots in such a manner that the centrifugal force is normal to the flat copper, thus minimizing the specific pressure on the insulation.

The coils are substantially held in the slots by means of Parsons manganese bronze wedges. The revolving field is thus formed as a smooth-surface cylinder, no matter what the number of the poles, thereby reducing the windage loss, besides tending to quieter operation than is possible with constructions which use projecting poles.

Ample spaces are allowed at regular intervals between the laminations or discs of the core, to provide for ventilation of the core itself and of the coils, air being drawn in through openings formed parallel with the axis and discharged at the periphery. The ventilation of the ends of the coils is attained by allowing them to project beyond the ends of the core in such a way that they can be thoroughly cooled; the coils at this point being firmly secured against the effect of centrifugal force by means of nickel-steel rings which form an extension of the core, and are provided with openings for the passage of the ventilating air current.

Generator Shaft

In revolving masses having high rotative speed there is, of course, a tendency to vibration, should the mass be out of balance even to the slightest extent, and if the natural period of such vibration should approximately coincide with the period of vibration of rotation, the cumulative effect may become serious. This is a matter that is too frequently lost sight of by designers and has resulted in dangerous vibrations in many badly proportioned revolving fields.

In the Allis-Chalmers generator particular attention is paid to this feature, and for each machine there have been determined such proportions of shaft as will cause the two periods of vibration to be as widely apart as possible, thus insuring safe and steady operation with minimum tendency to vibration.

Ventilation and Muffling

For the purpose of obtaining adequate ventilation and for muffling the noise produced by the circulation of the air, the Allis-Chalmers Company's turbo-generators are enclosed in such a manner that the air is taken in at the sides of the machine, passing through fans which discharge it over the end connections of the armature coils into the bottom of the machine, whence it passes

through the ventilating ducts of the core to an opening at the top of the machine.

This system of ventilation is most efficient, as the air which is used for cooling the stator passes through a large and unobstructed area at the outer circumference of the stator, whereas any method of ventilation in which the air passes radially from the inside to the outside of the machine necessitates the forcing of this air through the narrow spaces between the coils. The coils, furthermore, deflect the air so that ventilation of this kind is inefficient, requiring a large amount of power and resulting in poor cooling.

Overspeed Tests

On account of the high speeds of steam turbines and their generators, persons not accustomed to such speeds naturally feel some anxiety as to their perfect safety. This feeling has not been diminished by accidents that have occurred to a number of turbo-generators of a type of construction which the Allis-Chalmers Company has avoided; and, for the purpose of reassuring purchasers, the Allis-Chalmers Company has adopted the policy of testing every turbine and generator in its works to a speed 20 per cent in excess of the rated speed, thus subjecting the material to stresses 44 per cent above the normal. This overspeed test taxes the machine as it can not be taxed in practice, as even should the main governor fail to work, the safety governor will stop the turbine long before it reaches such a speed.

A 5000-kw turbine has been examined by the committee which was installed in the Williamsburg station of the Brooklyn Rapid Transit Company. This machine was started March 27 and has been running practically constantly ever since, carrying from full load to 50 per cent overload. The machine runs very smoothly and is apparently giving satisfactory results. There was an accident to the first row of blades at the high-pressure end due to a foreign substance getting into the machine. The cause of this was due to the carelessness of some person leaving in the casing a knife when the machine was being erected. This was discovered on April 25 after the machine had been in operation practically one month. We have received photographs and a description giving the full details of this accident. The photographs are

not clear enough to be reproduced but can be seen by those interested.

Shortly after starting up on the morning of April 25, a peculiar noise was heard in the turbine cylinder and the turbine was shut down and opened up. It was found that a piece of steel had become lodged between the spindle and the shroud of the first row of stationary blades and, acting like a lathe tool, had cut into the body of the drum for a width of about three-eighths inch and for a depth of nearly three-sixteenths inch, this cut being alongside of and opening into the groove which holds the first row of spindle blades as shown on the attached sketch. This had loosened a calking strip which held the ring of blades in place. For a distance of five or six inches this strip had come partly out of its groove, thereby loosening the ring of blades. This latter, under the influence of centrifugal force, had bent outward so that the channel-shaped shroud ring had rubbed hard into the bore of the cylinder. This rubbing had been so severe that the flanges of the shroud ring had worn almost down to the heads of the riveting which holds the shroud ring to the blades. The most important point is, not a single blade had come out or even become loosened or injured in any way.

The remedy consisted of removing one ring of blades, closing the cylinder and putting the turbine back into service; and at a convenient time a new set of blades will be installed. The condition of the removed blades is shown in the photographs.

An investigation as to the cause of this mishap showed that the piece of steel which had cut the groove in the shaft was apparently one of the leaves of a pocket-knife handle. A further search discovered the remainder of the metal parts of the knife, but the outer covering of the handle had disappeared. The large blade of the knife shows that it also had been rubbing hard. Parts of the knife are now in the possession of the Allis-Chalmers Company.

TURBINES SHIPPED OR UNDER CONSTRUCTION BY ALLIS-CHALMERS COMPANY

Utica Gas and Electric Co..................	1	1500-kw 2-phase 60-cycle 2500-volt
Transit Development Co.....................	1	5500-kw 3-phase 25-cycle 6600 and 11.000-volt

Westchester Lighting Co.	1	1500-kw 3-phase 60-cycle 13,200-volt
New York Edison Co.	1	1500-kw 2-phase 62.5-cycle 2500-volt
Dayton Lighting Co.	1	1500-kw 3-phase 60-cycle 2500-volt
Brooklyn Edison Co.	1	5000-kw 3-phase 25-cycle 6600-volt
Memphis Consolidated Lighting and Power Co.	1	1500-kw 3-phase 60-cycle 2500-volt
City of Jacksonville, Fla.	2	500-kw 3-phase 60-cycle 2300-volt
Western United Gas and Electric Co.	1	500-kw 2-phase 60-cycle 2200-volt
Kokomo, Marion & Western Traction Co.	1	1000-kw 2-phase 60-cycle 2300-volt
The Milwaukee Electric Railway and Light Co.	3	1500-kw 3-phase 60-cycle 2300-volt
Western Canada Coal and Cement Co.	3	1000-kw 3-phase 60-cycle 600-volt
Muncie Electric Light Co.	1	500-kw 3-phase 60-cycle 2300-volt

Mr. I. E. Moultrop, one of the members of the committee, visited Europe early this spring to investigate the turbine experiences in England and on the Continent. His report is hereto appended, together with a brief description of some of the turbine stations visited.

It will be noted in the very large list of turbines now installed that they are being manufactured in large numbers and that three large manufacturing companies are devoting a large part of their works to the manufacture of steam tur-

bines. There are also some other companies engaged in experimental development. These, however, have not reached a point of commercial importance in the larger-sized turbines for us to be able to express any satisfactory opinions.

We desire to take this opportunity of thanking the manufacturers and the engineers of the manufacturing companies for the very courteous attention that we have received at their hands, and for the valuable data that they were always ready to place at our disposal.

As it has been stated in the body of this report that the turbine has been developed into a standard piece of machinery and is being manufactured in large numbers, we believe the work of this committee is practically finished, and therefore recommend that it be discharged.

Respectfully submitted,

Committee,
W. C. L. Eglin, Chairman,
I. E. Moultrop,
J. D. Andrew,
W. E. Moore,
A. C. Dunham.

BOSTON, MASS., April 30, 1906.

W. C. L. EGLIN,

Chairman Turbine Committee National Electric Light Association.

Dear Sir—I have the honor to submit to you some notes that I made upon the turbine situation in England and on the Continent during my recent trip abroad.

There can be no doubt as to the status of the turbine as a prime mover in the generation of electrical energy by use of steam, for all of the recently designed stations which were visited were equipped with turbines, and some of the older stations, built originally with engine-driven units, are being increased in capacity by the installation of turbine units. The only observed instance in which this is not true is that of the Metropolitan station in Paris, where the station is being completed by the installation of one large engine-driven unit. This station was originally designed for, and about seven-eighths equipped with, engines, and doubtless the design of the station and the local conditions would, in this instance, make the installation of a turbine very inconvenient. It is rather interesting to note that in interviews with the leading engineers no question was ever raised as to the comparative merits of engines and turbines for electric light plants.

As an illustration of the standing of the turbine in England, it will be interesting to mention that the British Government decided the first part of this year that many of the naval vessels now under construction should be equipped with turbines in place of engines for propelling the boats.

The horizontal-shaft type of turbine is practically the only one used, and from the European engineers' standpoint, it fills their requirements much better than a vertical-shaft machine could possibly do. It is quite common practice with them to mount the exciter for an alternating-current unit on an overhung extension of the generator shaft and this method of excitation seems to give very good results. It tends to simplify the station equipment, has the advantage of driving a very small generator with the same economy as that of a large unit, and without any of the losses from the conversion of energy such as would occur in a motor-driven exciter. So far as could be learned, no serious difficulty has been experienced from fluctuations in the excitation voltage

by reason of speed variations of the turbine caused by sudden or wide changes of load on the main generator. Another advantage of the horizontal type was noticed in the Municipal station at Essen where they furnish both high-tension alternating current for power and lighting and 600-volt direct current for trolley cars. The peaks on these two systems do not overlap. A 5000-kw turbine unit is installed with an extra long generator shaft carrying a 5000-kw alternator, a 1500-kw direct-current generator, and also the exciter for the alternator. This combined unit was only a few feet longer than it would have been had the direct-current generator been omitted, and the combination saved the installation of a 1500-kw turbine to drive the direct-current machine, making the station simpler in its arrangement and cheaper to build.

No difficulty with the lubrication of horizontal bearings was found anywhere. The usual practice is to supply these bearings with an abundance of oil under considerable pressure so that the shaft is partly floated, and in addition the bearings are usually water-jacketed.

The regulation of the turbine is almost invariably accomplished by means of a governor controlling one valve in the steam-supply pipe, the steam being either throttled or admitted in puffs. The majority of the manufacturers use the latter arrangement. None of the manufacturers is attempting to regulate by cutting in or out a series of nozzles and this portion of the turbine construction is therefore very simple and positive. Close regulation is very easily obtained and turbine-driven alternators of different sizes were seen working in parallel, also working in parallel with engine-driven units and apparently without setting up cross-currents sufficient to be at all troublesome.

Much attention is being paid at present to the matter of blading turbines. Nearly all of the manufacturers are using blades made of extruded or drawn metal and secured to the shaft of the rotor by calking strips, and there seems to be no difficulty in obtaining a secure fastening in this manner. The Parsons company and its licensees, both in England and on the Continent, are lacing the turbine blades near their outer ends with an oval lacing inserted in a manner similar to that adopted by the American Westinghouse people some time ago, and described in the turbine committee's report of last year. This method of lacing seems to work satisfactorily so long as the blades do not rub, but

apparently all of the manufacturers who are using this construction are having trouble with the stripping of blades whenever the rubbing becomes very excessive. It was noted that in all of the stations visited, where this type of blading was used, there has been experienced, at some time or other, more or less trouble from the stripping of blades. This is one of the points that is now receiving a good deal of attention by both turbine designers and turbine users.

In the Zoelly turbine, the blading is done quite differently; the blades are cut out of strips of flat sheet steel, which is first milled wedge-shaped so that when finished the tips of the blades are much thinner than their roots. The blades are then shaped, polished, inserted and riveted into a light steel disc. No shrouding or lacing is used to support the blades. As no large installations of Zoelly turbines were visited, it is impossible to say from observation whether or not they had much trouble from losing blades, but from the fact that this machine is quite short for its diameter, it would be natural to suppose that there would be less trouble from stripping blades than in machines of the Parsons type.

The Willans and Robinson Company, at Rugby, have brought out a new form of blading which is attracting much attention and is one that would seem to be less liable to blade troubles than the older form of Parsons blading. They are using the Fulleger and Sankey patents and their blading is practically identical with that of the Allis-Chalmers Company in this country, which is fully described in another portion of this report. It may be interesting to note in this connection that this method is so well thought of that the Willans and Robinson Company have just closed a contract with the Cunard company to furnish the blading for the two new 25-knot turbine boats that the company is now building.

There seems to have been very little progress made in the matter of steam consumption of turbines during the past year. The best record of economy appears to be that of the Brown-Boveri 5000-kw machine installed in Frankfort a year or more ago. Apparently, the manufacturers have given more attention in the past year to the matters of standardization and of continuity of service than to economy requirements.

Improvement has been made in the design of turbine-driven alternators, chiefly in the matter of ventilation and eliminating

noise. It now seems to be the general practice to enclose the alternator entirely and provide forced ventilation either by means of fans on the shaft at either end of the rotor which pull the air in from the ends, force it through the machine and discharge it through a short funnel at the top of the housing, or air is forced in by an external fan at the bottom of the housing and through the generator and then is allowed to escape through a short funnel at the top.

Direct-current turbine-driven generators are now being built as large as 2000-kw which give very good results. The Brown-Boveri Company succeeds in getting a good commutation in these machines, apparently, by using large, well-built commutators and setting one carbon brush in advance of the others on the brush holder to take what little sparking there may be at times. The Parsons company builds a grooved commutator and uses copper brushes. It also finds it desirable to set one brush a little in advance of the others on the same stub. Large direct-current generators of both makes were seen in operation and in all cases the commutation was very satisfactory, and, in spite of the high speed, the wear on both commutator and brushes seems to be remarkably small.

The British Westinghouse Company has manufactured quite a number of turbines of the double-flow type, and installations of this type were seen at Brighton municipal station and the Neasden station and Lots Road station supplying current to the underground system of London. The chief advantage of this type is that the balancing pistons are dispensed with. Steam is brought to the longitudinal centre of the rotor and flows toward either end. It first passes through what is practically a Curtis single stage at either side of the steam inlet and then through the usual Parsons type of intermediate and low-pressure stages. The result is that the length of the rotor is materially lessened, and by making each end of the rotor do one-half the work, the steam pressure acting in opposite directions balances the rotor and thus eliminates end thrust. This type requires two separate connections to the condenser and seems to give little trouble provided the vacuum is maintained exactly the same at either end of the rotor. This construction of the rotor materially reduces the length of the machine and because it is so short there is less difficulty from unequal expansion in either the rotor or the casing than in the case of machines built on the single-flow principle.

Another new type of turbine was seen at the works of the Allgemeine Elektricitäts-Gesellschaft which gives promise of developing into a very satisfactory machine. It is a modified Curtis turbine with horizontal shaft and is somewhat different from the machines previously turned out by this company. A 3000-kw machine was seen in the company's turbine works which had been running under test for a considerable period of time. The rotor is built up with two regular Curtis double stages followed by eight Curtis single stages. The blading is formed from drawn or extruded metal. The wheels of the rotor are each made up of two steel discs with a groove in the periphery to receive the blades and the whole structure is then riveted solidly together. Special care is taken in building up the rotor to have it in good running balance, and before the rotor is assembled in the machine it is tested out in a balancing machine at the speed under which it is normally to operate. The peripheral speed of this machine is somewhat higher than in any of the other existing types of turbines and, to insure that it is not exceeding safe limits, the rotor is tested under a speed much higher than normal running speed before being assembled in the machine. The nozzles and the angle and spacing of the bucket are such that there is no end thrust on the shaft and a thrust bearing is therefore dispensed with. A short test on this 3000-kw machine, with 175 pounds steam pressure, 190 degrees Fahrenheit superheat and 93 per cent vacuum, gave a water rate of 13.2 pounds per kilowatt-hour, and the manufacturer has expectations of bettering even this very high economy.

The regulating of this machine is accomplished by the usual type of governor operating a balanced valve so that the steam flows in a steady stream and is throttled in proportion to the load on the turbine. The whole machine is very compact, quiet running, and fully self-contained. The oil pump for supplying oil to the bearings is operated from the turbine itself and the entire unit impresses one as being very simple.

It seems to be the general custom abroad for the turbine manufacturers to supply and install the condensing apparatus. Some of the manufacturers even build the condensers and pumps. Surface condensers are used almost universally and the Edwards type of pump is quite common. The usual practice is to install the condenser underneath the turbine in the basement of the sta-

tion and place an Edwards type air pump with a motor-drive alongside the condenser. Very good vacuums are obtained with this type of condensing apparatus. Where a very high vacuum is desired, the Parsons company has introduced what is called a steam augmenter to accomplish practically the same purpose as would a dry vacuum pump. This augmenter is virtually a steam ejector and uses steam from the turbine to exhaust a portion of the air from the condensed steam space of the condenser. This device has not been in use for any great length of time and it was not possible to get any very accurate data as to its efficiency.

Two turbine installations were seen where, for the purpose of economizing floor space, the surface condenser was installed in a vertical position. In one station, the apparatus has only just been installed and is too new to get any reliable information as to the performance of a vertical condenser. In the other station, the apparatus had been in for a considerably longer period of time and was not giving complete satisfaction. Part of the difficulties, however, were undoubtedly due to other reasons than because the condenser was built with vertical tubes.

Centrifugal pumps are used quite extensively to lift the circulating water from the source of supply and pass it through the condenser.

Figure 12 is an exterior view of the Saint Denis station. Usine de la Societé d'Electricite de Paris, Quai de la Seine. This is one of the most modern, up-to-date turbine stations on the Continent. At the left of the four chimneys are the coal bunkers, which are of brick and concrete construction roofed in. The long building running parallel with the chimneys and to the right is the turbine room, and between it and the chimneys is located the boiler house. On the right of the turbine room, in an annex, is the switch house. Coal for the station is received in barges, which come up a small stream the far side of the station; this stream also supplies the condensing water.

The transmission system leaves the station underground in a concrete and brick tunnel, one side of which is exposed in the picture and is seen running from the end of the turbine station to the extreme left of the picture.

This station is at present equipped with four 5000-kw Brown-Boveri turbo-generator units, generating 10,000-volt, three-phase current, and the station is to be immediately increased by the addition of six more similar units.

One striking peculiarity of the station is the feed-water arrangement for the boilers. A room is partitioned off at the end of the boiler house adjacent to the turbine room, in which are located all the boiler-feed pumps; the devices for indicating the water level in each boiler, and also valves for controlling the feed to each boiler. The water tender is stationed in this room and has full control over the water for every boiler without going into the boiler room proper.

Figure 13 shows a cross-section of the turbine room and switch house, in which it will be noted that the turbines are

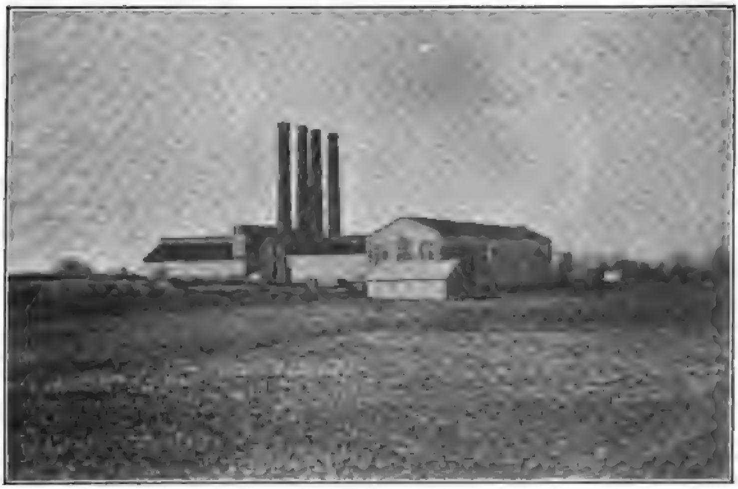


FIG. 12—ST. DENIS STATION, PARIS

installed in two parallel rows lengthwise of the building. The condensing apparatus is installed on the basement floor; the condensers are immediately underneath the turbines; the air pumps are placed at one end of the condensers; and the circulating water pumps, which are of the vertical centrifugal type, are submerged in a well beneath the basement floor and driven by motors.

There are two inlet tunnels, shown at the bottom of the cut, supplying water to a well for each turbine, and the two wells for each pair of turbines are cross-connected. Valves are installed so that either well can be cut off from the circulating water

system and emptied to facilitate repairs. The discharge tunnels are located at a higher level and in about the centre of the turbine room.

The switching is all in the small annex to the turbine room.

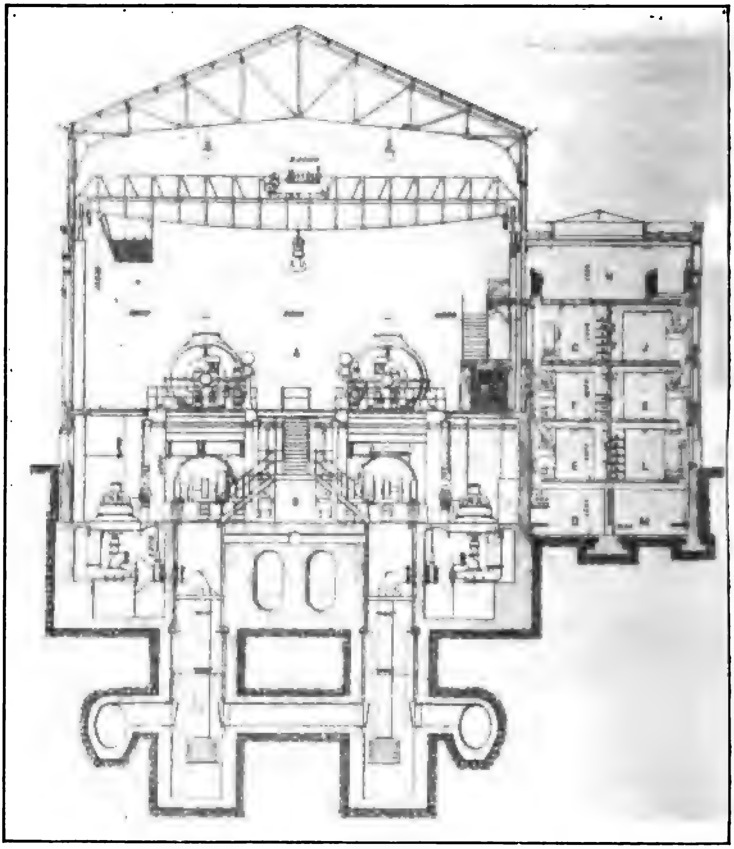


Fig. 13—Cross-Section of Turbine Room and Switch House, St. Denis Station

The three lower floors of the switch house are separated from the turbine room by the building wall. The two upper floors at present open into the turbine room, but are arranged so that they may be partitioned off if desired later.

The basement is a cable vault. The next three floors contain

the 'bus-bars, oil switches and field resistances for the generators, and the upper floor, which is the operating room, contains the

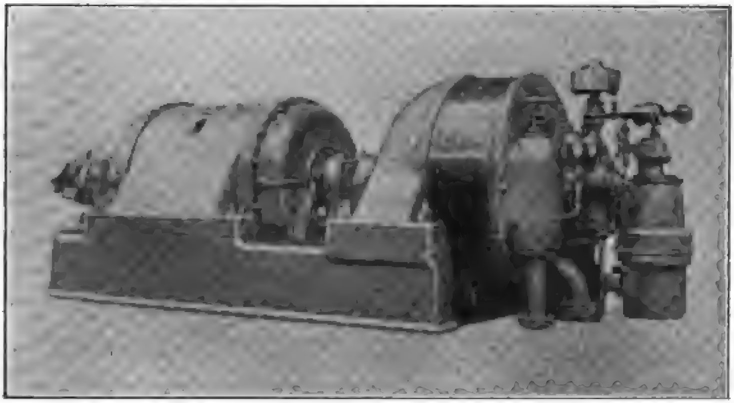


FIG. 14—1000-KW ALLGEMEINE-ELEKTRICITATS-GESELLSCHAFT TURBINE

instruments and the control for the switches. No motor-operated switches are used. The operating tables are so arranged that the

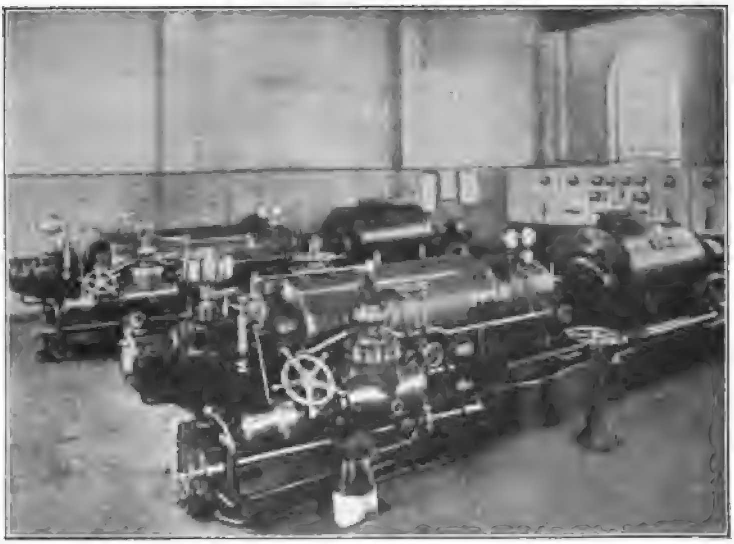


FIG. 15—TWO 500-KW BROWN-BOVERI TURBINES

switches can be conveniently thrown by hand by means of rods and bell cranks connecting the switch handles on the operating

table to the switches themselves. The barriers, switch cells, and the 'bus-bar compartments are all of reinforced concrete.

Figure 14 shows a 1000-kw three-phase turbo-generator built

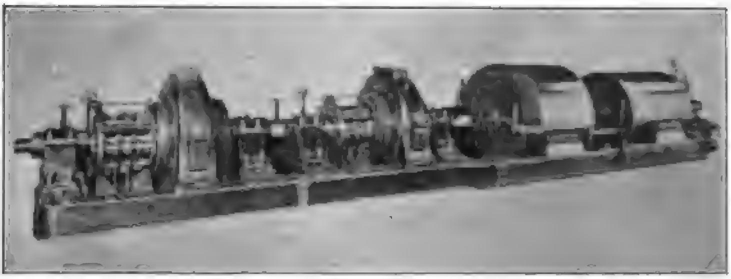


FIG. 16—1500-HP ZOELLY TURBINE

by the Allgemeine Elektricitäts-Gesellschaft, Berlin. This machine runs at a speed of 3000 revolutions per minute.

The cut very clearly shows the extreme simplicity of this

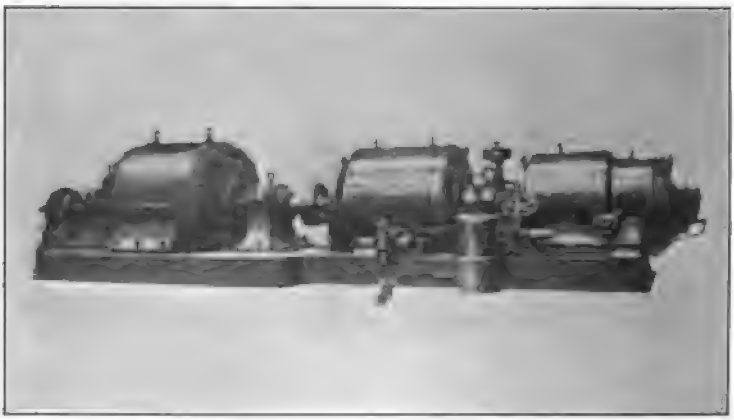


FIG. 17—RATEAU TURBINE BUILT BY ATELIERS DE CONSTRUCTION, OERLIKON

machine. All of the governing and regulating mechanism is located at the end of the turbine.

Figure 15 shows two 500-kw Brown-Boveri turbo-generators installed to operate a coal mine at Herne.

The manufacturer's catalogue states that these machines are run at 155 pounds steam pressure superheated to 250 degrees centigrade and generate at 1000 volts. This installation was made in the spring of 1904. All of the operating and regulating mechanism is shown mounted at the end and on the front side of the turbine and this apparatus is much simpler than it would appear in the cut.

Figure 16 shows a 1500-hp Zoelly turbo-generator built by Escher Wyss and Company, Zurich.

This turbine runs two three-phase generators made by Siemens-Schuckert Werke and is installed in the central station, Berlin.

Figure 17 shows a 1000-kw, three-phase turbo-generator built by the Ateliers de Construction, Oerlikon.

It should be noted that the governing and regulating mechanism is installed between the high and low-pressure stages of the turbine and on the front side of the machine. The exciter is shown coupled to the shaft of the turbine at the left-hand side of the generator.

Following is a list of the turbine manufacturers visited and to whom the writer wishes to make acknowledgment for the courtesy and attention which he received. In all instances, the companies were pleased to receive visiting engineers and to show them through their works and also the details of the manufacturing.

Manufacturers

C. A. Parsons Manufacturing Company, Newcastle-on-Tyne, England.

Richardson Westgarth and Company, Hartlepool, England.

Willans and Robinson, Rugby, England.

Walls End Slipway Company, Newcastle-on-Tyne, England.

Société John Cockerill, Seraing, Belgium.

Allgemeine Elektricitäts-Gesellschaft, Berlin, Germany.

Brown-Boveri and Company, Baden, Switzerland.

Escher Wyss and Company, Zurich, Switzerland.

Ateliers de Construction, Oerlikon, Switzerland.

Compagnie Française Thomson-Houston, Paris, France.

Respectfully submitted,

I. E. Moultrop.

Mr. Farrand: I move that the steam turbine committee be thanked for its continuous service, for the reports it has given us during the past three years, and that the committee be discharged.

(The motion was carried.)

The President: Is there any discussion on the report? The Chair does not see any one who wishes to discuss the paper. As there is evidently too much in it for us to take up and discuss in a general way, we will pass on to the next paper on the programme, which is on *Mechanical Refrigeration,* by Mr. John Meyer, of Philadelphia.

Mr. Meyer presented the following paper:

MECHANICAL REFRIGERATION

The author is much indebted to J. Ingles Matthias for the valuable assistance rendered in collecting and tabulating the data contained in this paper.

INTRODUCTION

At the present time central-station interests are scanning the field for sources of revenue other than that derived from the sale of current for arc and incandescent lighting.

Mechanical refrigeration, having as its source of power the electric motor, is an outlet for our product and deserves much consideration. The paper before you deals with this subject, practically new from a central-station point of view, and having an almost unlimited application in the preservation of food products, the maintaining of low temperatures in many industrial processes, and the domestic and household use where ice apparently reigns supreme.

In some cases the adoption of mechanical refrigeration will depend almost entirely upon the question of economy; in other cases the cost may be an important factor, which, however, may be offset by conditions manifestly important, such as cleanliness, convenience, controllable temperatures and the freedom from annoyances incidental to the use and handling of ice.

Refrigeration is now applied to dwellings and public halls, not only to replace the ice in refrigerators, but to furnish cooler and better air during the hot season of the year.

The principle of mechanical refrigeration as employed to-day is not new, following as it does the established laws of physics. It is within the scope of this paper to discuss the elementary principles involved.

The machines now used to produce a reduction in temperature are nearly all based on the principle of production of cold by the evaporation of liquids to the gaseous form. Preference is given to either ammonia, sulphurous acid or carbonic acid, as the evaporating liquid.

CHOICE OF REFRIGERATING MEDIUM

By the term "ice-refrigerating effect" is meant the production of an amount of cold equivalent in heat units to the amount of heat that would be necessary to melt a certain weight of ice.

The refrigerating effect of the liquid or medium depends on the latent heat of evaporation per pound.

The size of the compressor depends on the number of cubic feet of vapor that must be taken in to produce a certain amount of refrigeration and the strength of its parts on the pressure of the medium used.

The loss of refrigeration on account of cooling the refrigerating medium depends on the specific heat of the liquid as compared with the heat of volatilization.

These factors are indicated in Table I.

TABLE I.

	Pressure in Pounds per Square Inch at 0° F.	Heat of Vaporization per Pound at 0° F.	Volume Cubic Feet per Pound at 0° F.	Specific Heat of Liquid.	Heat of Vaporization per Cubic Foot.	Relative Volume of Compressor for Equal Refrigeration.	Loss Due to Cooling Liquid.
Sulphurous acid	10	171.2	7.35	0.41	23.3	61.70	0.24%
Carbonic acid.............	310	123.2	0.277	1.00	447.	3.24	0.81%
Ammonia	30	555.5	9.10	1.02	61.7	23.3	0.18%

Anhydrous ammonia is selected as the refrigerating medium on account of the low percentage loss due to cooling medium, the higher total refrigerating effect, its non-corrosive effect on iron and steel, being perfectly safe to handle with properly constructed apparatus.

The ammonia occurs in practical refrigeration in three different forms, as the liquid anhydrous ammonia (that is free from water), the gaseous anhydrous ammonia, and solutions of ammonia in water of various strengths.

At ordinary temperatures the ammonia, or anhydrous ammonia, as it is called in its natural condition, is a gas or vapor. At a temperature of thirty degrees Fahrenheit it becomes liquid at the ordinary pressure of the atmosphere, and at higher tem-

peratures also if higher pressures are employed; thus, ammonia will remain a liquid only when kept at a temperature of thirty degrees Fahrenheit below zero on that scale, and at the usual temperatures, say seventy degrees Fahrenheit, it will be kept a liquid only by maintaining it under a pressure of 115 pounds above the atmosphere. With a reduction of pressure the liquid becomes a vapor, withdrawing from surrounding objects the heat necessary to change its state. The heat of vaporization at atmospheric pressure is 573 British thermal units.

SYSTEMS OF GENERATION

The systems of generation in vogue at the present time, which may be called commercially successful, are, respectively, the absorption system and the compression system.

THE ABSORPTION SYSTEM

The principle involved in this system of ammonia refrigerating is the absorption of ammonia gas or anhydrous ammonia by water.

Advantage is taken of the property of water, or of a weak hydrate, whereby it shows a strong avidity to dissolve in itself the dry ammonia gas. At fifty-nine degrees Fahrenheit water will absorb 727 times its volume of ammonia vapor.

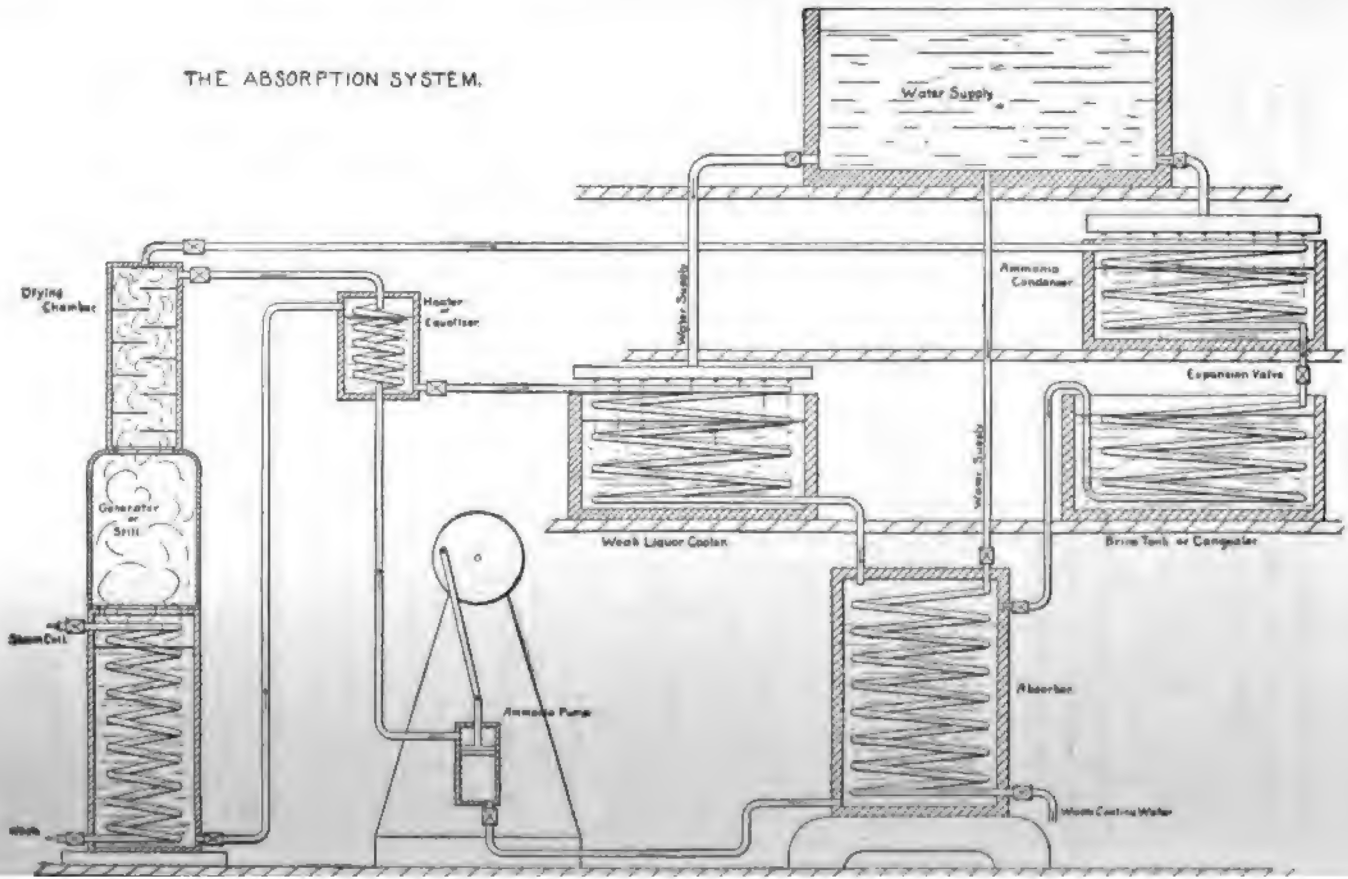
In this system there are four distinct processes, respectively: First, the generation of gas; second, the condensation of gas; third, the expansion of gas; fourth, the absorption of gas. These four processes form a continuous cycle and, being constantly repeated, the process is made continuous.

The *generator* (see diagram Figure 1) is the apparatus in which the anhydrous ammonia is driven in a gaseous state from the aqua ammonia by heat, raising the pressure to from 120 to 160 pounds per square inch. The heat is supplied by steam coils. At this pressure anhydrous ammonia may be reduced to a liquid by cooling.

In the *condensation* process the ammonia is passed through condenser pipes which are brought in contact with cold water. In giving up heat the ammonia gas is condensed to a liquid.

In the *expansion* process the refrigeration is produced. The liquid ammonia, at a high pressure, passes through a minute opening in the expansion valve into the expansion coils with low

THE ABSORPTION SYSTEM.



pressure, changing the liquid into the gaseous state, absorbing heat from the pipes and producing refrigeration.

The *absorption* process involves the absorption of the ammonia gas thus generated, by the weak liquid contained in the absorber.

The *absorber.* The duty of the absorber is the reverse of the generator. The process of separation into ammonia gas and weak liquor in the generator is brought about by supplying heat. In the absorber the weak liquor and the ammonia gas reunite, requiring that the absorber be provided with water-cooling coils to reduce the temperature of the contents, thus forming a strong aqua ammonia.

In the *equalizer* the two liquids pass through separate coils in close proximity to one another. The weak liquor, as it leaves the generator, contains excess heat which must be removed before it reaches the absorber. On the contrary, the strong aqua ammonia should be delivered to the generator from the pump at as high a temperature as possible. A distinct gain is secured by a transfer of heat as indicated.

The object of the *weak-liquor cooler* is to remove the heat from the weak liquor before entering the absorber. It is built similar to the condenser and utilizes water for cooling purposes.

The only part of the plant mechanically operated is the small ammonia pump that transfers the liquid from the absorber to the generator.

THE AMMONIA COMPRESSION SYSTEM

Of the systems of artificial production of ice and mechanical refrigeration in extensive use to-day, the ammonia compression system undoubtedly occupies a pre-eminent position. The medium or refrigerant used is anhydrous ammonia.

The process consists of a complete cycle involving three successive steps. They are called, respectively, *compression, condensation* and *expansion.* These three steps are made continuous and are constantly repeated. The ammonia is kept confined. Thus the same ammonia is used repeatedly, the supply simply being replenished from time to time, as losses unavoidably occur.

At the beginning the ammonia is in the gaseous state, and at not far from the atmospheric pressure and temperature.

For the *compression* process a compressor is used, which is nothing more or less than a specially designed pump. The

compressor is used to compress the ammonia to a pressure of from 125 to 175 pounds per square inch. The gas in the beginning, as in the case of bodies in general, contains a certain amount of heat. After compression it contains practically this same amount of heat it had before compression. This heat is sufficient, even at the increased pressure, to maintain the ammonia in the gaseous state. Hence at the end of the compression process the ammonia is still a gas.

The second, or *condensation* process, consists in removing this excess of heat. For this process a condenser is used. This consists of an arrangement of pipes for the ammonia, in contact with cold water. The ammonia gives up the excess of heat to the cold water, and is in consequence reduced to a liquid.

It is in the *expansion* process that the refrigeration is produced. What might here be called the refrigerator consists of a network of pipes arranged according to results desired. The compressor draws its supply of ammonia from these pipes. In consequence the pressure in the same is maintained comparatively low, being possibly from fifteen to fifty-five pounds per square inch. The liquid ammonia at the high pressure given is allowed to enter these pipes with low pressure. The result is that the ammonia, being relieved of the high pressure, changes from a liquid to a gas. The gas thus formed is reduced in temperature considerably below the freezing point of water. It is thus in a condition to absorb heat from the pipe system that encloses it, which it speedily does. As the pipes are supposed to be arranged in the spaces to be cooled, these supply the heat which the ammonia absorbs, thus becoming reduced in temperature and accomplishing the results desired.

The essential parts of the ammonia compression system are shown in diagram Figure 4.

COMPARISON OF SYSTEMS OF GENERATION

In both systems the refrigerating medium is compressed, liquefied and then expanded; the cooling condenser, the expansion valve, the brine-cooling appliance and its pumps being identical. In the absorption system the compression has been accomplished by the direct application of heat; in the compression system by mechanical means.

The Compressor

The important feature of an ammonia compression system of refrigeration is to be found in the compressor.

The object to be desired is the ability to pump the greatest amount, by weight, of gas with the greatest economy of operation. There are many constructive details in valves, etc., in the different makes of compressors, though the principal difference is due to different methods in which superheating of the gas during compression is prevented, or to whether the compressor is horizontal or vertical, double or single-acting, and so forth.

It is impossible to build a compressor which discharges every particle of compressed gas. Whatever is left in the cylinder at the moment the piston begins the suction period will re-expand and fill up a certain space, thus reducing the volume of the entering vapor, or, in other words, the displacement of the compressor.

To decrease the work required to compress the gas, attempts are made in various types of compressors to cool it during compression by the use of water-jackets, or by the direct injection into the cylinder of either liquid ammonia or oil.

More or less loss is caused by leaks through valves and pistons.

It is needless to say that the compressor should be of subtantial construction.

Ammonia Condensers

There are three types of condensers built.

The submerged condenser consists of a water tank of steel or wood, in which liquefying coils of extra heavy pipe are submerged in cold water, so arranged that as the supply of water is fed into the bottom of the tank, it will be evenly distributed around the coils and the warm water taken from the top surface. This style of condenser is most generally used for small plants, but when it is necessary to use muddy water, the atmospheric condenser is more desirable, on account of being more convenient to keep clean.

The atmospheric condenser (Figure 2) is built up of straight lengths of extra heavy pipe, with return bends, usually in stands, each stand being connected with gas and liquid headers

and provided with valves at inlet and outlet, so that any stand can be shut off without interfering with the operation of the others. An air or blow-off valve is placed at the highest point of each stand. A uniform flow of water over the pipes is secured by means of galvanized iron troughs especially constructed for the purpose, placed along the top rows; the pipes being spaced sufficiently wide apart to secure the greatest benefit from the combined action of the water and the evaporating effect of the air. The hot gas from the compressor is first admitted to the

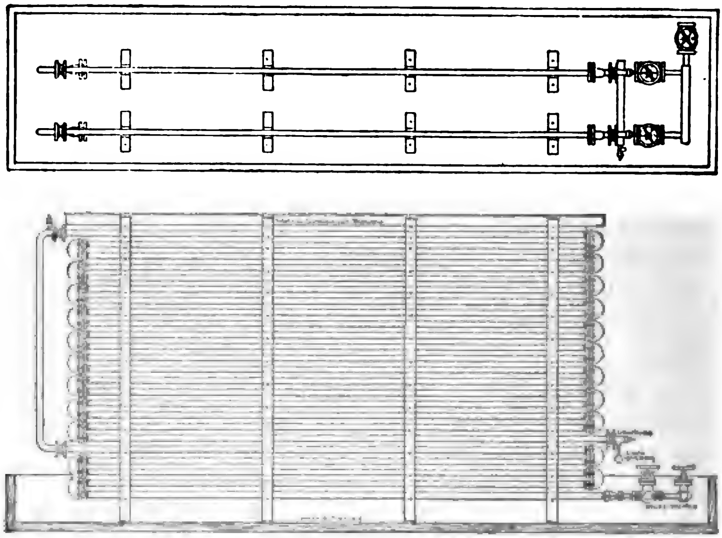


FIG. 2—ATMOSPHERIC CONDENSER

bottom pipes, bringing the hottest gas in contact with the warmest water, and after being partially cooled in the lower pipes, the gas is carried through the top of the condenser when it has a downward flow in the same direction as the water, the liquid ammonia being carried off near the bottom.

A simple atmospheric coil condenser is constructed of oval coils of heavy pipe, welded and made continuous. This avoids the large use of joints at the bends.

The double pipe condenser (Figure 3) combines many features of both the submerged and atmospheric styles. It is con-

structed with a pipe within a pipe made up in stands with double return bends. The ammonia gas is admitted to the outer pipe at the top and the water supply to the inner pipe at the bottom; this gives a downward flow to the ammonia and an upward flow to the water, bringing the warmest gas in contact with the warmest water and *vice versa;* the liquid ammonia passes from the condenser at the bottom at the same temperature as the initial water.

This style of condenser is very effective; the gas in its down-

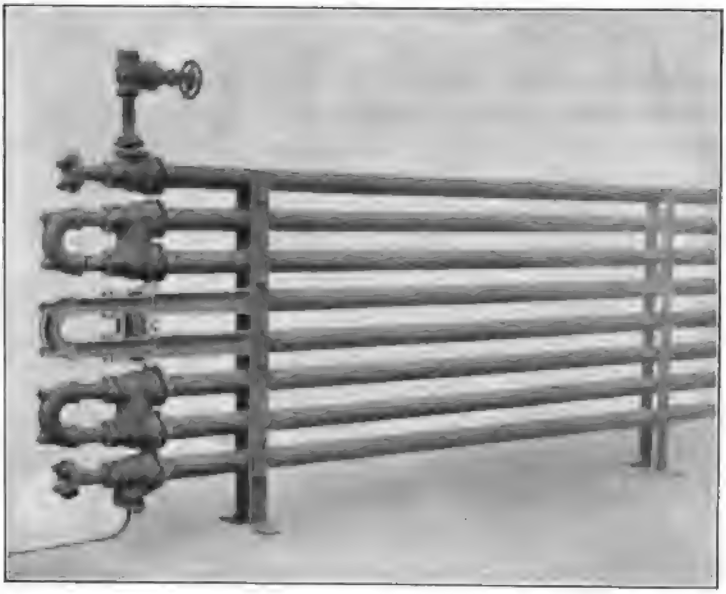


FIG. 3—DOUBLE-PIPE CONDENSER

ward travel through the space between the two pipes is rapidly cooled by contact with the inner water pipe, and also from the cooling effect of the atmosphere on the outside. It is not essential to use water on the outside, consequently there is no necessity for drip pans or water-tight floors. The condenser can be placed at any level, and the water carried to any height above, that may be desired; it requires less room than any other style; the return bends for the water pipe are provided with plugged openings to permit the cleaning of the pipes.

A somewhat greater efficiency can be obtained by connecting the water supply to a trough along the top row and sprinkling the water over the outside of the pipe, as well as through the inner pipes.

Liquid Ammonia Receiver

The liquid ammonia receiver is a tank, preferably cylindrical, holding about half a gallon of ammonia for each ton of refrigerating capacity (in twenty-four hours). It is placed between the condenser and the expansion valve to receive and store the liquefied ammonia.

Ammonia Expansion Valve

This valve is placed between the liquid receiver and the expansion coils. The valve is a peculiar one, admitting of very fine adjustment, enabling the admission of the required amount of liquid to the coils. The least movement of the expansion valve causes variations in the back pressure.

Expansion Coils

The expansion or volatilization of the liquid ammonia, by which refrigeration is effected, takes place in series of coils of iron pipe, placed either in the room to be refrigerated or they may be placed in a bath of brine or water, the latter liquids being circulated in rooms to be refrigerated.

Purge Valve

At the highest point of the condenser a purge valve should be provided for, to let off permanent gases.

Thus far we have discussed only the two systems of producing cold. To utilize the cold produced by the absorption or compression systems, two methods are in use, the first of which is called the direct-expansion system, and the second is known as the brine-circulating system.

THE DIRECT-EXPANSION SYSTEM

In this system the expansion coils are placed directly in the rooms to be cooled and either on the ceiling or side walls. The

direct system is simpler and less expensive to install and to maintain, but has the disadvantage that refrigerating effect is produced only during the operation of the compressor unless some form of cold storage is provided (Figure 4).

Where the direct expansion system is preferred and it is not desirable to operate the compressor continuously, brine storage tanks can be placed in the upper portion of the rooms to be cooled, a portion of the expansion coils placed in the brine tanks and the brine cooled to a low temperature (Figure 4A). Sufficient storage may thus be obtained to maintain an even temperature over non-operative hours.

THE BRINE CIRCULATING SYSTEM

In this system the ammonia-expansion coils are submerged in a tank containing a saline solution, such as chloride of calcium or chloride of sodium, which is cooled to a low temperature. The ordinary method employed to abstract heat from the brine is to enclose the brine in a tank in which are placed the expansion coils. The anhydrous ammonia entering the expansion coils vaporizes, extracting the heat from the brine and returns as a gas to the compressor. The chilled brine is circulated, by means of a circulating pump, through the coils suspended in the room to be cooled.

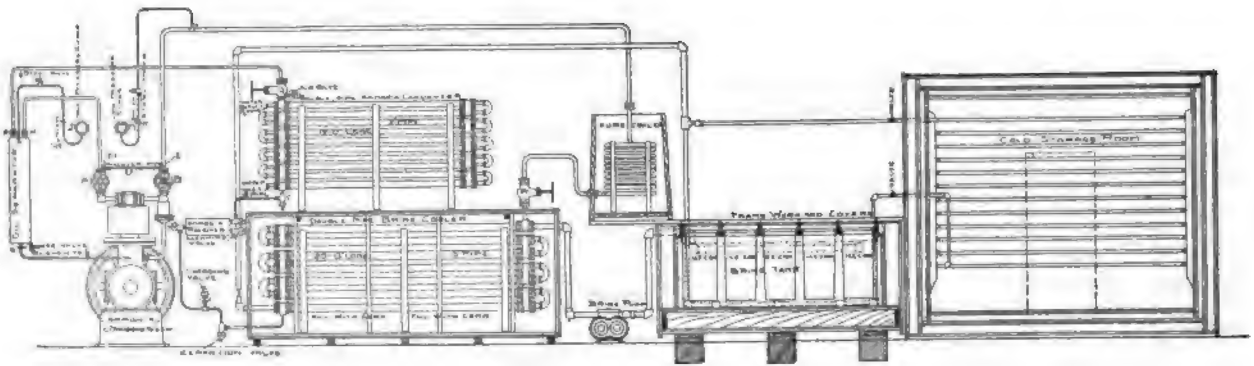
The cold brine in its passage through the pipes becomes warmer by reason of its taking up heat from the rooms, and it is finally returned to the brine tank, where it is again cooled by the expansion coils. The operation is continuous.

Condenser and Back Pressure

The lower the pressure and temperature in the condenser coil, and the higher the pressure and temperature in expanding coil (back pressure), the more economical will be the working of the plant. For these reasons the cooling water on the condenser should be used as cold as it can be had and in as ample profusion as possible.

INSULATION

When we remember that all refrigerating apparatus is only a means of removing heat, and that all insulation is only a means



-ELEVATION-

FIG. —DIRECT EXPANSION SYSTEM

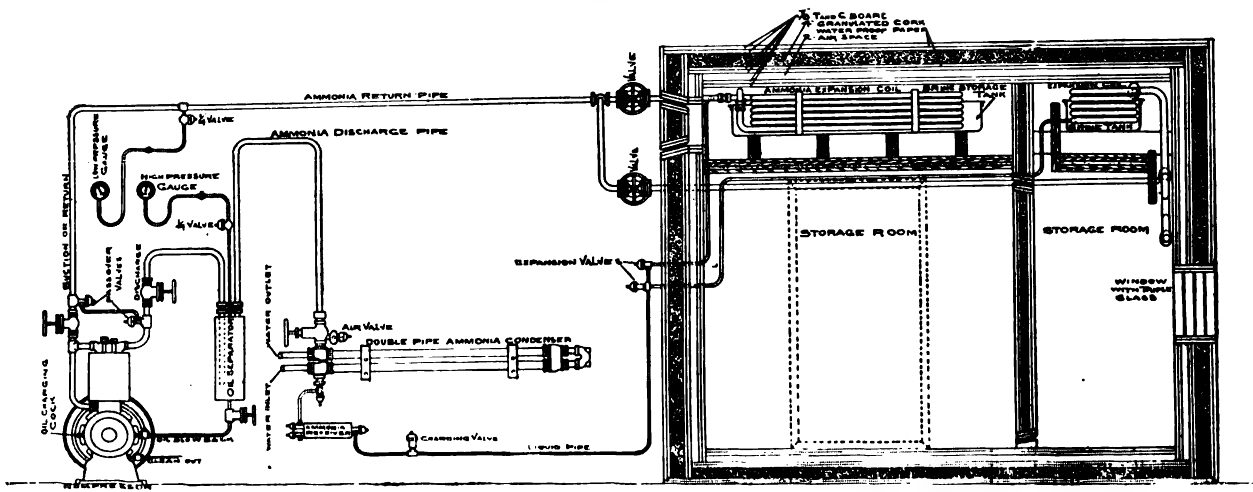


FIG. 4A—DIRECT EXPANSION BRINE STORAGE

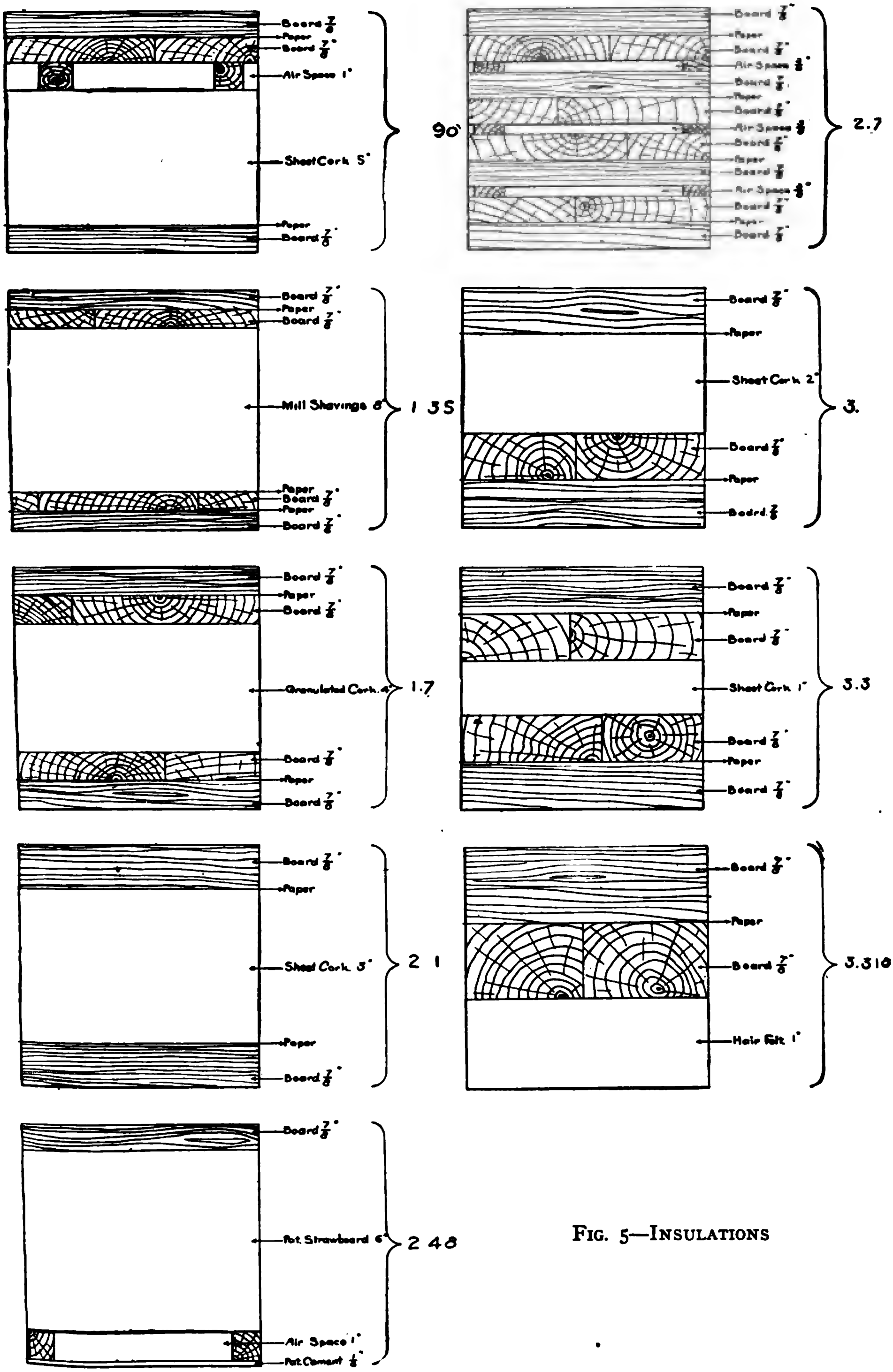


FIG. 5—INSULATIONS

of preventing its return, it is clear that the machine and the insulation are factors of equal importance in the refrigerating plant. It would therefore be reasonable to suppose that positive knowledge of one would be as available as the other, which is not entirely true.

Heat is conveyed from the exterior to the interior of cold storage rooms by three agencies—convection, conduction and radiation. Leakage of heat into cold storage rooms is due principally to conduction—that is, the conveying of heat through

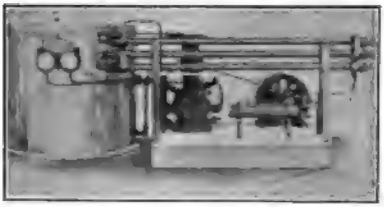


FIG. 6—WATER-COOLING PLANT

walls themselves—and to convection, or by the circulating of air in the spaces within the two or more portions of the wall. Loss of heat can be lessened by changing the materials and the thickness of walls, which can be more readily understood by examining the following table and the corresponding diagrams of insulation. (Figure 6.)

The heat transmitted per degree difference in temperature per square foot surface in 24 hours in B. t. u. for differently constructed rooms is given below:

TABLE II.

Double boards and paper, one-inch air space, five-inch sheet cork paper and seven-eighths-inch board	.90
Double boards and paper, one-inch air space, four-inch sheet cork paper and seven-eighths-inch board	1.20
Two seven-eighths-inch boards and paper, eight-inch mill shavings and paper, two seven-eighths-inch boards and paper	1.35
Same slightly moist	1.8
Double boards and paper, four-inch granulated cork, double boards and paper	1.7
Two seven-eighths-inch boards and paper, eight-inch mill shavings and paper, two seven-eighths-inch boards and paper (damp)	2.1
One seven-eighths-inch board and paper, three-inch sheet cork paper, one seven-eighths-inch board	2.1

One seven-eighths-inch board, six-inch patent silicated strawboard (air cell), finished thin layer patent cement	2.48
Four double seven-eighths-inch boards with paper between (eight board) and three three-eighths-inch air spaces	2.7
One seven-eighths-inch board, paper, two-inch sheet cork, two seven-eighths-inch boards and paper	3.
Two seven-eighths-inch board and paper, one-inch sheet cork, two seven-eighths-inch boards and paper	3.3
Two seven-eighths-inch double boards and two papers, one-inch hair felt	3.318

Confined air, commonly classified as "dead air," is recognized to be the most perfect protection against the transmission of heat, but it must be confined, that is, must be enclosed so as to prevent its motion; otherwise there would be air-currents and a great deal of heat would be conveyed from the exterior to the interior of the refrigerating rooms. Air spaces should be divided into small volumes, thus reducing circulation to a minimum.

All heat entering a cold storage room must be removed by the operation of the refrigeration machine or the melting of ice. This means the expenditure of power and the loss of money. Money expended in the best insulation can not be better invested, as an inferior insulation means a higher operating cost.

Insulated doors should be capable of being opened and closed easily and quickly; they must be thoroughly insulated, and so fitted that when closed the joints at the top, sides and bottom will be practically airtight.

There is constantly a leakage of heat from the exterior to the interior of cold storage rooms so long as a difference of temperature exists between the two sides of the insulating medium. Walls that appear to be of ample thickness are found to be poorly insulated, due in some cases to improper insulating materials and in others to careless construction and bad design. The kind of material used in insulating is very important.

In choosing a substance there are other qualities besides its insulating powers to be taken into consideration; for instance, its ability to withstand moisture. This is of the utmost importance, inasmuch as at a very low temperature moisture from the air is readily absorbed by many materials, resulting in fermentation and decay. The following comparisons will be of interest:

The heat transmitted per degree difference in temperature per square foot of surface in twenty-four hours in British thermal units for similarly constructed rooms under various conditions is given below:

Two seven-eighths-inch boards and paper, eight-inch mill shavings and paper, two seven-eighths-inch boards and paper	1.35
Same, slightly moist	1.80
Same, damp	2.10

Good insulation should have the following characteristics:

High efficiency.
Durability.
Lightness.
Ease of application.
Minimum of space required.
Minimum attraction for dampness.
Odorless.
Low cost.

AIR CIRCULATION

The tendency of the contents of cold storage rooms to become tainted or otherwise injured depends largely upon the distribution and movement of the air. A certain amount of circulation would occur regardless of the position of the cooling pipes. It is advantageous, however, to produce the greatest air circulation with the fewest pipes, and to arrange the pipes so as to have as much head room as possible.

Figures 7, 8, 9, 10, 11 and 12 illustrate the circulation of air under various conditions. Since cold air sinks to the floor and warm air rises, the ceiling would appear to be the proper place to locate the cooling pipes.

Circulation depends upon a difference in temperature, and is possible only when air that has been cooled and sinks can be replaced by warmer air from above. The more rapid these changes, the more rapid circulation will be.

In order to produce satisfactory circulation, two things are necessary; first, there must be a layer or stratum of comparatively warm air above the cooling pipes to take the place of that which is cooled and sinks to the floor, and, second, the cold air descending must not interfere with the upward current of warm air. To insure non-interference, aprons are provided to direct the course of the air, as indicated in Figures 11 and 12. The short partitions shown in the drawings serve to give to the warm and cold currents the necessary direction of flow. The more per-

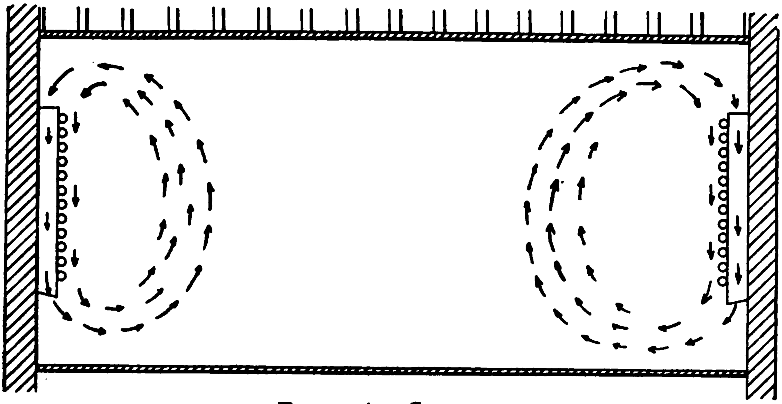


FIG. 7—AIR CIRCULATION

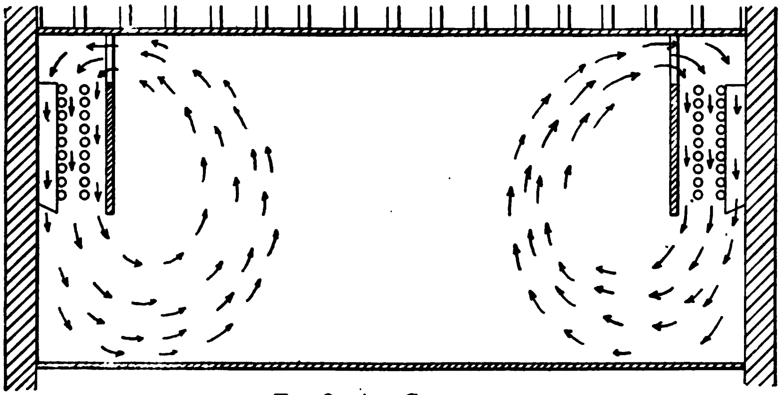
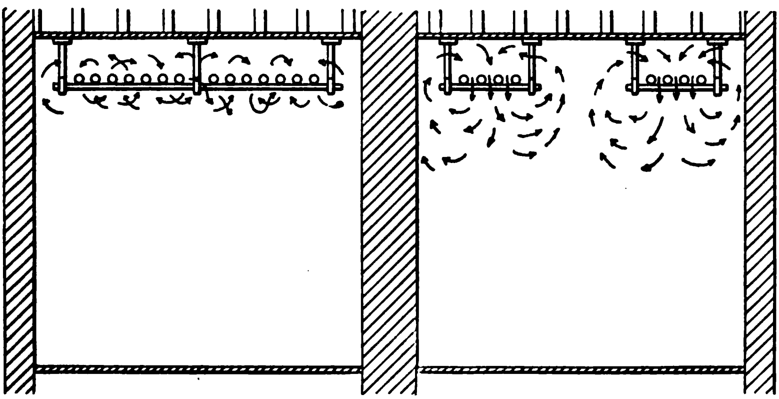


FIG. 8—AIR CIRCULATION



FIGS. 9 AND 10—AIR CIRCULATION

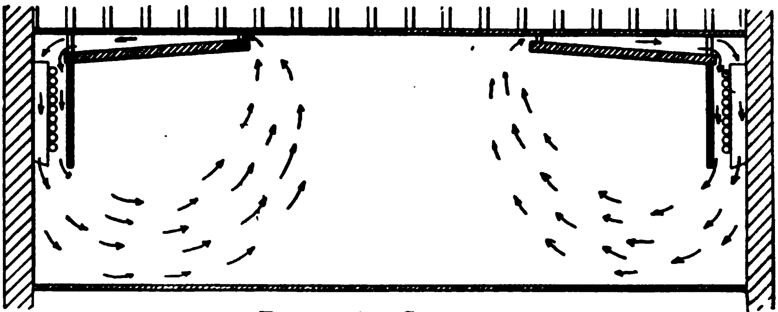


Fig. 11—Air Circulation

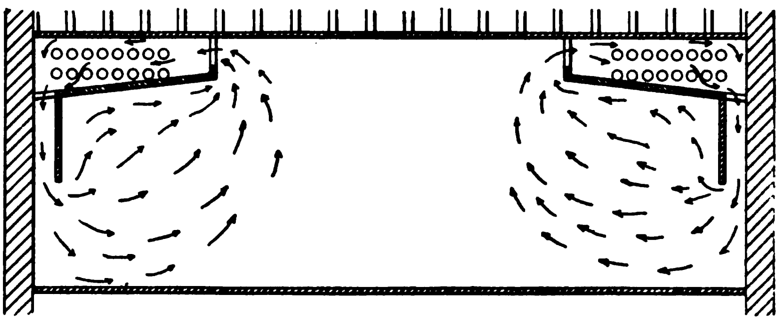


Fig. 12—Air Circulation

fectly these conditions are met the more thorough and rapid will be the circulation.

THE STANDARD TON OF REFRIGERATION

The quantity of refrigeration is now expressed in tons of ice melting.

As the latent heat of ice is 142 B. t. u., it takes for melting one ton of 2000 pounds of ice of thirty-two degrees the quantity of $2000 \times 142 = 284{,}000$ B. t. u.

THE CAPACITY OF THE MACHINE

In speaking of the "capacity" of the machine as being so many tons "ice-refrigerating effect," or "ice effect," or "refrigerating effect," or "ice-melting effect," we mean the production of an amount of cold in twenty-four hours equivalent in thermal units to the amount of heat necessary to melt so many tons of ice

at thirty-two degrees Fahrenheit to water at thirty-two degrees Fahrenheit.

Each ton thus melted requires	284,000	B. t. u.
Each pound " "	142	B. t. u.

The capacity of the machine is proportional, almost entirely, to the weight of ammonia circulated. This weight depends on the suction pressure and the cubic displacement of the compressor pumps.

The foregoing data involve only the principles of mechanical refrigeration. About two years ago the Philadelphia Electric Company detailed an engineer to solicit this class of business. With the able assistance of the Advertising Bureau many inquiries were received and contracts closed, the consumer introducing the equipment at his own expense. We succeeded in securing installations in different lines of business. Tests were made and the data tabulated and recorded for ready reference. The results follow:

APPLICATIONS

DRUG STORE

The largest drug store in the city, centrally located, doing a large soda-fountain business, for which the refrigerating machine was principally installed. The conditions were the usual ones, of the ice being brought into the store once or twice per day, broken, and placed in the fountain at the top, resting on coiled three-eighths-inch block-tin pipes, through which flows the beverage from cylinders in the basement to the soda-fountain spigots. The dispenser of soda-water desires it as near thirty-two degrees Fahrenheit as possible, but is rarely able to maintain a temperature below forty to forty-five degrees, by reason of improper insulation due to door in top of fountain, warm air about the cylinders and the gradual rise of temperature as the atmospheric temperature rises and the bulk of ice falls.

Details of Equipment

The drug store above mentioned had three large fountains, one of which was out of service, and the refrigerating system installed was what may be called sweet-water circulating. In the basement was installed a 7.5-hp direct-current motor (belt), driving a three-ton refrigerating machine (see illustration),

directly expanding into an insulated tank filled with sweet water, the suction coil returning directly to the machine. From this tank runs a coil to one of the three fountains on the floor above, where it manifolds at back and inside of lower compartment of fountain, and so continues to the two others where, at the third, it rises and empties into the upper compartment, submerging the beverage coils and overflowing to the second fountain, and from there to the third, from which it returns to the tank, the cir-

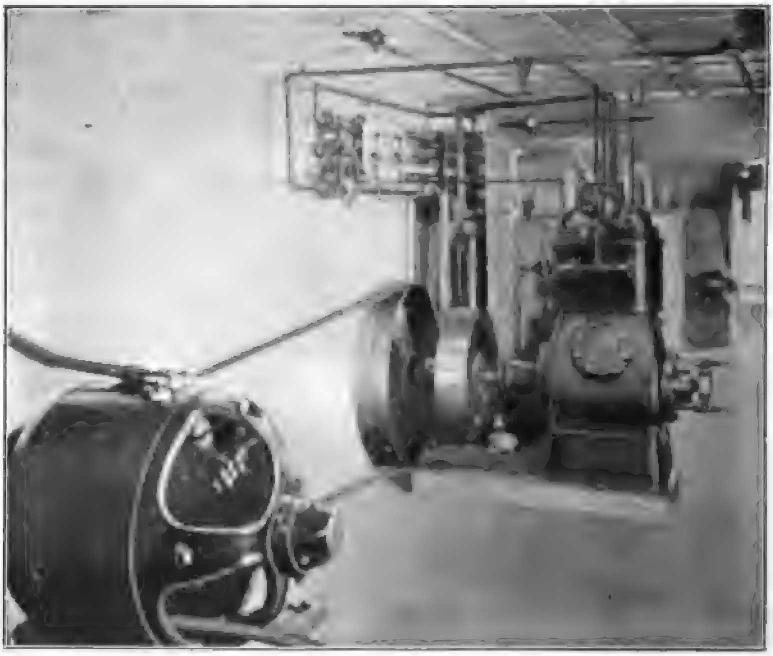


FIG. 13—THREE-TON PLANT—DRUG STORE

culation of the water being effected by a small rotary pump driven by a 1-hp direct-current motor. There is an additional chilled-water circulation to cold-storage room, located in the basement, of the following dimensions: 6′ 6″ × 6′ 9″ wide × 16′ 6″ long, in which temperature is maintained at 40 to 45 degrees Fahrenheit.

The plan of operation of the above is to operate the machine for sufficient length of time to make enough ice on and about

expansion coils in the water tank, with consequent low temperature in the fountains and cold storage room during operative and non-operative hours of the machine and to maintain the desired temperature until next day. This chilled sweet water is circulated, as described, by operation of the 1-hp motor. The purpose of manifolding the coils in the lower soda-fountain compartments is to refrigerate the bottled goods in same.

TEST OF PLANT

Compressor motor, 7.5-hp.	Average length of time of operation (from 7 a.m.) was	4 hrs. 45 min.
	Average daily consumption in watts..	17,426
Pump motor, 1-hp.	Average hours' operation	14 hrs. 50 min.
	Average daily consumption in watts..	8,118
	Temperature of circulating water was	32° F.

The complete monthly meter readings for this refrigeration plant were as follows:

					Watts.
September	17	to	September	23	259,400
"	23	"	October	21	661,000
October	21	"	November	18	704,200
November	18	"	December	16	498,800
December	16	"	January	10	620,600
January	13	"	February	10	682,800
February	10	"	March	10	554,800
March	10	"	April	7	679,800
April	7	"	May	5	659,600
May	5	"	June	2	729,800
June	2	"	June	30	908,600
June	30	"	July	28	1,054,400

Comparison of Ice versus Mechanical Refrigeration

After the refrigeration plant was installed all of the (three) fountains were put in service, this being equivalent to an ice consumption representing a cost of $820.86, to which should be charged the time of two employees of the place for two hours each morning throughout the year, amounting to $249.60, making the aggregate amount chargeable to refrigeration $1,070.46.

The account chargeable to the electrically-driven refrigeration plant to furnish refrigeration for the above-named units is as follows:

Power for one year (based on average of 11 months)	$579.00
Interest 5 per cent (on entire refrigeration plant, $2,100)	105.00
Water, for condensing purposes	9.00
Depreciation and repairs, at 10 per cent	210.00
Oil, waste, etc	50.00
	$953.00

Representing a saving of $117.46 in favor of mechanical refrigeration.

Advantages Obtained

In addition to the saving indicated above, the advantages of mechanical refrigeration utilizing the electric motor as the source of power are obvious, prominent among which are avoidance of ice deliveries, with the attending slop and inconvenience, the time necessary to get the ice in condition and in place, constant temperature under control, and furnishing a temperature of 33 degrees as compared to 40 to 45 degrees with ice, securing dry air refrigeration in lower compartments of fountain, and so on.

DAIRY

Dairy Conditions

As most city milk depots receive their milk from a number of different dairies under varying conditions, they pasteurize it by heating to a temperature of 150 to 160 degrees Fahrenheit to purify and sweeten it and prevent bacterial development.

After pasteurizing, the milk is run over pipes or discs—depending on kind of pasteurizer—through which city water circulates, cooling milk to about 90 degrees Fahrenheit; then over another set of pipes or discs through which brine circulates, thus cooling milk to about 35 degrees Fahrenheit.

At this latter temperature bacterial development is reduced to a minimum, which the following table will show:

INCREASE IN NUMBER OF BACTERIA

	At 93° F.	At 54° F.
In 1 hr. multiplies	7.5 fold	None
" 2 hrs. "	23 "	4 fold
" 3 " "	64 "	6 "
" 4 " "	215 "	8 "
" 5 " "	1830 "	26 "
" 6 " "	3800 "	435 "

At 35 degrees Fahrenheit it multiplies less in proportion; in fact, it is said by dairymen that bacteria do not develop below 40 degrees Fahrenheit, consequently they try to keep the milk at 35 degrees Fahrenheit.

Before mechanical refrigeration was adopted the dairymen practically cooled the milk twice. The ice used in brine was lost

and after milk was placed in uninsulated storage room, in bottles, it was necessary to ice it.

With mechanical refrigeration the pasteurized milk upon leaving cooler enters filling tanks and is immediately run into bottles, capped and placed in storage room. The milk seldom enters storage room higher than 37 degrees Fahrenheit, consequently very little work is necessary to reduce milk to 35 degrees Fahrenheit, at which temperature it is kept until following morning, when it is placed in wagons for delivery.

The hours of machine operation vary from four to ten hours

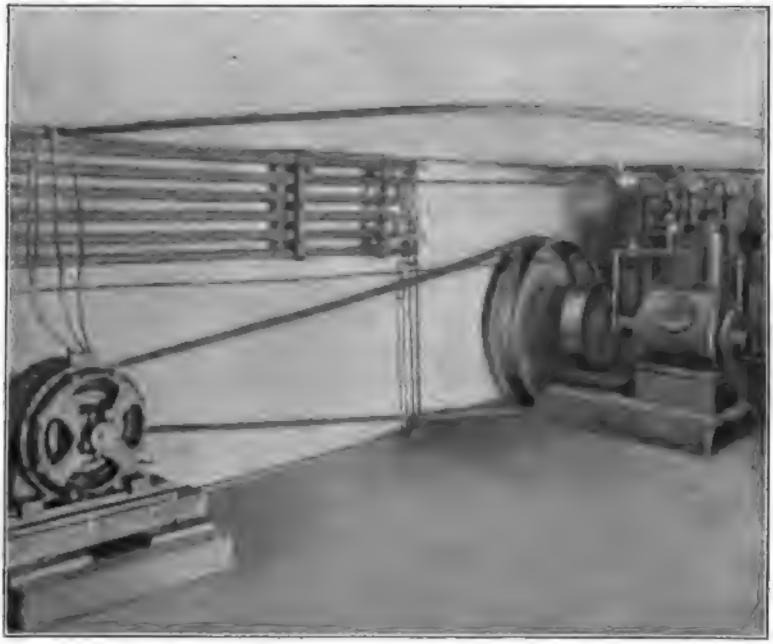


Fig. 14—Three-Ton Plant—Dairy

per day, depending upon outside temperature, and during the winter months the machine is idle much of the time.

The following description is of a dairy plant originally using ice and then introducing mechanical refrigeration.

Original conditions: Handling sixty 40-quart cans per day. Cooling the pasteurized water with ice and salt, and setting the milk (40-quart cans) in a large vat of water cooled with blocks

of ice. This vat had long been water-soaked, the floor was also in a water-soaked condition, and the surroundings unsightly and unsanitary. The plant was subject to the daily annoyance of the delivery of the ice, which had to be broken into different sizes with consequent loss of time and labor of the man, as well as waste of ice; and there was a constant rise of temperature in vat during the day.

Remedy Brought About by Adoption of Mechanical Refrigeration

Water-soaked vat was removed and floor cemented. A 3-ton refrigerating machine operated by a 7.5-hp, alternating-current, two-phase motor was installed (Figure 14). A cold storage room was constructed having a floor space of 14′ × 13′ × 11′ high, with head room of 6.5′. In top of room are placed a series of six iron tanks, 36″ × 30″, containing a brine solution. In addition to direct expansion coils in brine tanks, there is also a coil around side of room to help keep temperature in room down during pasteurization when brine in tanks is used for cooling pasteurized milk.

The above dairy was using for refrigerating purposes, now furnished by machine, 2300 pounds of ice per day during six months of the year, at $3.00 per ton, and 25 per cent of this amount for the remaining six months, a total of 259.75 tons, costing $779.25. The refrigerating plant and motor installed complete cost the owner $1765. Charging 5 per cent for investment and 10 per cent for depreciation and repairs—$264.75.

Actual cost of electric power for year..................	$525.31	
Water for condenser and jacket.........................	9.00	
Fixed charges..	264.75	$799.06
Cost of ice		779.25
		$19.81

Apparently indicating a saving of $19.81 in favor of ice.

In stating the cost of ice, however, the help to handle this ice has not been taken into consideration.

The comparison is not fair, as the ice was used during a cool winter and mechanical refrigeration during an open or warm winter. Had the average temperatures for the two seasons been the same, the cost of operation would have been very much in favor of mechanical refrigeration.

In addition, there are two important factors: first, temperature at will under sanitary conditions; second, the cost of electric power to effect the above being confined to temperature demands and refrigeration of larger amount of product.

We find that many machine people are not familiar with dairy conditions, even though they understand other lines of business thoroughly.

Regarding the conditions against which the central station must compete, we wish to say that steam is absolutely necessary

FIG. 15—200-POUND PLANT

in a dairy, for pasteurization and bottle washing. For pasteurizing alone it takes about as follows:

240	qts.	milk	per	hr.	requires	2-HP	boiler	(low	pressure)
400	"	"	"	"	"	3 "	"	"	"
800	"	"	"	"	"	5 "	"	"	"
1400	"	"	"	"	"	6 "	"	"	"
2600	"	"	"	"	"	8 "	"	"	"

This figure will be found useful where a dairyman talks steam drive and says he must have a boiler.

With the ice and salt method of cooling pasteurized milk it takes approximately three-quarters of a pound of ice to reduce a quart of milk to 40 degrees Fahrenheit, and a quarter of a pound of ice to ice up in cold storage room (minimum conditions).

For example: A dairy handling 2400 quarts of milk per day will spend about $3.60 for ice and get a temperature of 40 degrees. This does not take into consideration help to handle ice, or salt for making the brine. Mechanical refrigeration, using the electric motor as power, will cost not over $2.00 per day and furnish a temperature of 35 degrees or lower. Fixed charges not included.

GROCERY STORE

This installation consists of 200-pound refrigerating machine, operating about same number of hours during whole year, as store is kept at high temperature during winter.

The cost of ice per year was about		$192.20
Mechanical refrigeration as follows:		
Fixed charges	$ 40.00	
Cost of electric power per year	102.21	142.21
In favor of electrical refrigeration		$49.99

The machine is operated by a 0.5-hp direct-current motor, and is started and stopped by means of the usual motor switch, this being all the attention the apparatus has required since it was installed. The average operation is eight hours per day.

RESTAURANT

While the dairy, or any business where a hot liquid is cooled to a low temperature, requires considerable calculation, the restaurant is equally severe in that the refrigerators are usually in the kitchen, where the temperature is anywhere from 90 degrees in the winter to 120 degrees in the summer. The general provision and meat room is usually kept at 38 degrees; the fruit room at about 45 degrees; and the general kitchen box at about 40 degrees.

Before mechanical refrigeration was used, the ice was taken to kitchen or cellar, and there was considerable loss before being placed in refrigerator. In this case the mechanical refrigeration

TEST ON 500-LB. REFRIGERATING MACHINE

RESTAURANT

Date	Hours Running			Watt-Hours Consumed	Pressure		Temperature in Box	Running	Remarks
	Total Hours	Started	Stopped		Condenser	Suction			
Aug. 23	15	9.00 a.m.	12.00 m.n.	19,600	......	......	......	Yes	......
" 24	24	12.00 m.n.	12.00 m.n.	29,900	160	27.5	53	"	......
" 25	24	12.00 m.n.	12.00 m.n.	30,800	165	27.5	60	"	......
" 26	22¼	12.00 m.n. 6.15 a.m.	4.30 a.m. 12.00 m.n.	29,750	160	27.5	52	"	......
" 27	20	12.00 m.n. 6.45 a.m.	2.45 a.m. 12.00 m.n.	26,700	Not noted		Not noted		Sunday
" 28	19¾	12.00 m.n. 6.15 a.m.	2.00 a.m. 12.00 m.n.	26,000	150	28.0	53	Yes	......
" 29	20¼	12.00 m.n. 6.15 a.m.	2.30 a.m. 12.00 m.n.	26,100	150	30.0	48	"	......
" 30	9	12 00 m.n.	9.00 a.m.	11,550	145	30.0	50	"	......
Total	154¼	......	......	200,400	......	......	......	......	......
Oct. 18	15	9.00 a.m.	12.00 m.n.	19,300	......	......	.....	Yes	......
" 19	17	12.00 m.n. 7.00 a.m. 11.00 p.m.	1.00 a.m. 10.00 p.m. 12.00 m.n.	22,350	100	15.0	56	"	......
" 20	16½	12.00 m.n. 7.00 a.m. 10.30 p.m.	1.00 a.m. 9.00 p.m. 12.00 m.n.	21,400	25	25.0	58	"	......
" 21	17½	12.00 m.n. 7.00 a.m.	12.30 a.m. 12.00 m.n.	22.350	110	25.0	46		......
" 22	18	12.00 m.n. 7.00 a.m.	1.00 a.m. 12.00 m.n.	22,950	.....	.....	......	......	Sunday
" 23	4¼	7.00 a.m. 11.00 a.m.	9.30 a.m. 12.45 p.m.	4,800	65	27.0	43	Yes	......
" 24	6½	10.00 a.m.	4.30 p.m.	9,250	......	57.0	51	No	......
" 25	2	7.00 a.m.	9 30 a.m.	2,600	60	34.0	51	"	......
Total	......	......	......	125,000	......	......	......	......	......

necessitated a new box, which brought about another saving, namely, good insulation.

Direct expansion is used in this restaurant, as it is open 24 hours per day, and, owing to boxes being opened at short intervals during the 24 hours, the highest economy is obtained from direct expansion, as noted in column headed "suction pressure."

As no ice was used in this new cold storage room prior to installation of machine, the comparison between the cost of ice and electric power can not be made, but, from calculation, it would require approximately half a ton of ice, and since installing machine a tank for cooling drinking water, pumped to restaurant above, has been added to machine's work.

Based on the test, the cost of current for 365 days per annum would aggregate $351.86, while the equivalent amount of ice, 183 tons, at $3.50, would cost $640.50. The cost comparison would therefore be as follows:

Cost of electric power per year	$351.86
Interest (5 per cent) on cost of $400	20.00
Depreciation and repairs, 10 per cent	40.00
Water for condensing purposes	3.00
	$414.86
Probable cost of previous method	640.50
Difference in favor of present method	$225.64

BUTCHER SHOP

Only recently we closed a contract to supply current to operate an equipment. The plant is in course of construction and consequently no test data are available.

The following preliminary estimates show the comparison between the cost of ice and mechanical refrigeration in this class of business.

Dimensions of refrigerator: 9 feet in length by 6 inches width and 11 inches height, to contain meats and to maintain a temperature of 35 degrees Fahrenheit.

Proposed installation: One ton refrigeration machine outfit complete on one bed-plate, driven with 3-hp motor. Cost installed, $994. Hours of operation average eight hours per day, 312 days. Horse-power on basis of practice with other machines of same make, at rate of 1.7 horse-power per ton of refrigeration—

13.6 horse-power-hours per day $\times$ 312 = 4243 horse-power = 3165.4 kilowatt-hours at 10 cents, less 20 per cent=$253.23.

Cost of electric power	$253.23
Interest on investment, 5 per cent on $994.00	49.70
Depreciation and repairs, 10 per cent	99.40
Water for condensing purposes	3.00
	$405.33
Ice consumption, 1 year	425.00
Difference in favor of mechanical refrigeration	$19.67

In this plant a brine storage tank will be located in top of cold storage box, the system of refrigeration being direct expansion, to furnish refrigeration during the operative hours of the machine, at the same time storing work in brine, which takes care of room during non-operative hours, and will hold temperature in room from Saturday night until Monday morning.

The machine is capable of furnishing refrigeration, of temperature stated, for 300 additional cubic feet, and it is probable that the average daily hours of operation throughout the year will be less than eight.

RESIDENCES

A number of refrigerating machines having a capacity of 500 pounds have been installed recently, although no data of running conditions are available at this time.

In these installations, expansion coils are submerged in a brine solution, thus maintaining normal temperatures over non-operative hours.

A 1-hp motor is required to operate a 500-pound plant.

Preliminary test was made on one equipment with following results:

Average hours run per day	8 hours 29 mins.
Watt-hours during test	8954
Condensing pressure	100 to 105 lbs.
Back pressure	20 to 25 lbs.
Temperature in refrigerator	36°F to 45°F
Average temperature	39°F

In actual practice the watt-hours will be reduced.

SALOONS

Saloon, typical of all others in the city; seven and one-half barrels of beer delivered to the cellar about 7 A. M. daily, this

beer having a temperature of 40 to 70 degrees when received. By means of water-pump (furnishing compressed air into the barrels) the beer is forced up through three-eighths-inch block-tin pipe to lower compartment of bar above, where the pipes (from the respective barrels) are coiled and continued to upper bar compartment, where they are again coiled and end at the spigots, the cooling of the beer being effected by ice placed on the coils through removable lid at top of bar, and through door-

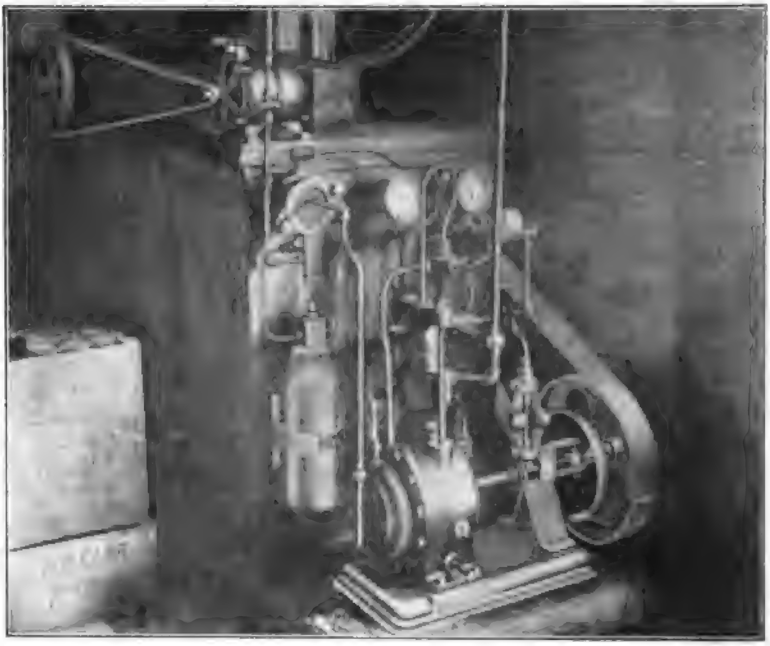


FIG. 16—500-POUND PLANT—SALOON

way of lower compartment. This is a crude and wasteful method, as by reason of the necessarily very poor insulation, the melting is excessive and the saloon is subject to the daily annoyance of ice deliveries. The system adopted for the saloon plant is the same as for the drug store, *i. e.*, the machine located in the basement expands directly into insulated tank filled with sweet water, this water being circulated by means of small pump driven by electric motor (Figure 16).

Saloon Data

Bar of seven spigots, average consumption of beer approximately 96 gallons each day.

Temperature of beer when received 40 to 70 degrees Fahrenheit.

Saloons are usually open from 15 to 18 hours each day.

Beer when drawn should have a temperature of 42 degrees Fahrenheit.

For Average Conditions

The refrigerating machine of 500 pounds' capacity is operated by a 1-hp direct-current motor. The circulating pump is operated by a one-eighth-horse-power motor. Compressor and pump are belt-driven.

In saloons it is not so much the cost as it is the nuisance of handling the ice provided, of course, the same temperature conditions can be obtained as with mechanical refrigeration.

Comparative Cost of Ice versus Mechanical Refrigeration

WATT CONSUMPTION

				Watt-Hrs.
December	28 to	January	21	124,300
January	21 "	February	18	28,400
February	18 "	March	18	135,400
March	18 "	April	15	226,900
April	15 "	May	13	192,600
May	13 "	June	10	207.600
June	10 "	July	8	322,700

The cost comparison is as follows:

Yearly cost of ice with previous method		$213.64
Cost of electric power for one year, based on average for seven months	$143.16	
Interest on cost of investment at 5 per cent	20.00	
Depreciation and repairs at 10 per cent	40.00	
Water for condensing purposes	3.00	
		206.16
Difference in favor of present method		$7.48

Temporary Substitute for Mechanical Refrigeration in Saloon

Repeated tests and practice indicate that to eliminate the ice in the bar it is necessary to circulate chilled water over the beverage coils, and to effect this an apparatus has been made (Figure 17), costing about $175 installed. It is operated with a

one-eighth-horse-power motor, and its chief value to the central station is that of an entering wedge for the electrically-driven refrigeration machine.

This apparatus is located in the cellar and filled with ice every morning, the operation of the same being as follows:

The beverage coils in bar, *1*, are submerged in water, *2*,

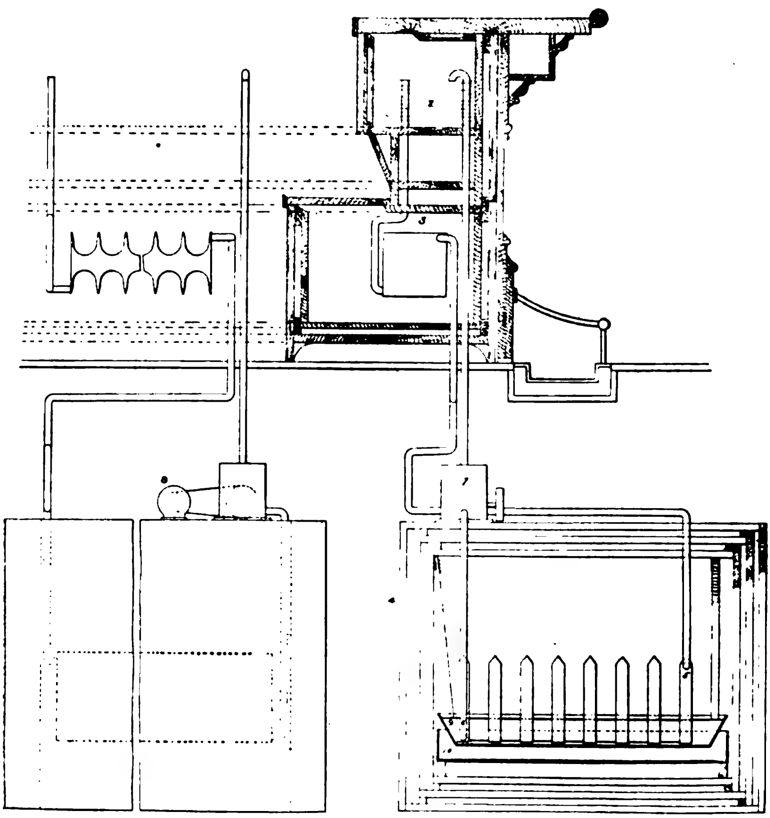


Fig. 17—Proposed Refrigerator for Saloons

which flows downward through lower bar and box, *3*, and refrigerating same to apparatus, *4*, where it enters can, *5*, and emerges at can, *6*, where by means of pump, *7*, driven by motor, *8*, it is raised to bar box.

The water cans are surrounded with cracked ice and the

lower part of the cans are submerged in the ice water in pan, *9*, which overflows into pan, *10*, from which is an overflow waste.

When the refrigeration machine is installed, the cans are removed and coils from the machine are placed in the box in lieu of same, and a one, two or three-horse-power motor installed to operate the machine, and the one-fifteenth or one-eighth-horse-power-motor retained to circulate the water.

BEER PASTEURIZING

While the beer bottler uses a pasteurizer, the work differs from that of the dairy in that they use mechanical refrigeration only to keep storage room cool, in which they keep kegs before bottling. The dairy pasteurizes the milk before bottling, while the beer bottler pasteurizes after bottling, using water at a temperature of 140 degrees Fahrenheit for 30 minutes, then using cold water for about 12 minutes.

Beer after bottling is kept at same temperature as atmosphere, consequently very little refrigeration is needed.

Pasteurizing beer is for the purpose of preventing fermentation of the yeast and permits the storing of beer in a warm place for from three to four weeks without showing the least cloudiness. Plant of 6-ton capacity now in course of construction.

ICE CREAM MANUFACTURING

Ice cream manufacturers have lately been seriously considering mechanical refrigeration for the manufacture of their product. We are at present trying to interest a firm who contemplate the installation of a 30-ton machine to operate not longer than 12 hours per day, and make 6000 quarts of ice cream.

PASTEURIZATION OF CREAM

Mechanical refrigeration in ice cream manufactories has brought about a desire for pasteurization of their cream, as it will keep for weeks and come out of cold-storage room pure and sweet, and free from germ life. It makes ice cream more palatable and of a more smooth and velvety texture than unpasteurized cream.

WATER-COOLING PLANT

Figure 6 represents a complete refrigerating plant for the cooling of drinking water, for about 25 or 30 drinking fountains.

This tank is of galvanized iron, insulated and provided with direct-expansion coils. Connected with the tank is a house pump for circulating continuously the ice water through the building. In some cases these fountains are on the various floors of the building, near the elevator shaft, and sometimes each office is equipped with a cold-water fountain in addition to the other water faucets at the wash basin. This method of furnishing ice water does away with the ice cooler and the bother of caring for the ice.

AUTOMATIC CONTROL

The various applications mentioned in this paper are entirely manual control. An automatic system has been developed, but unfortunately no plant of this type is in operation in Philadelphia, and we are therefore unable to present any data. The claims of the manufacturers are as follows:

The Automatic System of Mechanical Refrigeration—Ammonia-Compression Method

Any mechanical refrigerating plant not automatically regulated in its operation and in the performance of its functions requires the services of an attendant or an engineer to stop and start the machinery, and to adjust the hand-valves regulating the feed of ammonia to the expansion coils and of cooling water to the compressor and condenser.

With an *automatic system* these requirements, involving labor and regulation, are automatically accomplished:

First—The machine is stopped and started automatically according to the temperature required in the refrigerating box.

A special thermostat, adjusted to the temperature desired in the refrigerating compartment of box, operates so as to shut off the power automatically when the box is sufficiently cooled, and to start the machine again when refrigeration is required. This obviates the necessity of an attendant constantly watching the temperature.

Second—The feed of ammonia is automatically regulated by the pressure in the expansion coils.

An ammonia expansion valve automatically opens, throttles and closes the feed of liquid ammonia to the expansion coils,

giving not only better regulation than can be had from a hand-controlled valve, but eliminating manual labor.

Third—The feed of cooling water to the condenser and to the compressor is automatically regulated by the heat or pressure conditions in the condenser.

A waste regulator automatically controls the feed of water to the condenser pipes and to the compressor water-jacket, varying this feed according to requirements, thus effecting a saving in water and eliminating manual regulation.

Fourth—The machine is also automatically stopped whenever the condenser pressure reaches an excessive limit, and again started when this pressure falls to the normal.

A high-pressure cut-off automatically interrupts the ther-

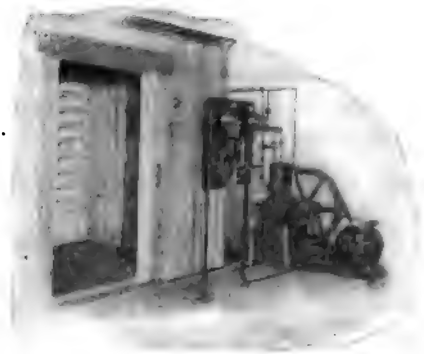


Fig. 18—Automatic Plant

mostat circuit so as to stop the machine if the condenser pressure is too great, and restores the control to the thermostat only after the pressure has fallen to or below its normal.

This insures against accident in the remote contingency that a dangerous pressure should arise from failure in the cooling water supply or from any other cause.

Eliminates the cost of constant attention.

Saves power-producing refrigeration only when necessary.

Saves water, required for cooling the condenser, and compressor cylinders.

Increases efficiency—machine always at full load when running.

Maintains uniform refrigerating temperature.

Secures greater accuracy of regulation than by manual attention, and therefore

Insures the economical use of independent plants, and widens the field for mechanical refrigeration with small plants.

LOAD FACTOR

In order that a simple comparison may be made between plants of different classes, or in the same class, we have adopted what is termed the "load factor."

The load factor is the relation between the full load in rated horse-power multiplied by 10 hours' use each day divided into the actual use in horse-power-hours each day, the result indicating the load factor in per cent.

Reducing horse-power to kilowatt and horse-power-hours to kilowatt-hours, the formula would read:

First—Multiply the kilowatts installed by 10 hours.
The result indicates the use of the full load 10 hours per day.
Second—Divide the kilowatt-hours (average) used each day by the result obtained by such computation.
Third—This result indicates the load factor in per cent

To illustrate:

The average kilowatt-hours delivered to the dairy as indicated in the comparison was 17.17. The connected load is 7.5 horse-power = 5.625 kilowatts.

The load factor $= \frac{17.17 \text{ K. W.}}{5.625 \times 10} = 30.52$ per cent, representing a use of approximately three hours per day of each kilowatt.

COST OF OPERATION—EFFICIENCY

The cost to the consumer of operating his plant is dependent upon the efficiency, and this is particularly true in the matter of mechanical refrigeration. It is to be expected that a higher first cost means a more efficient equipment, and the most economical point is reached when the first cost of equipment and the cost of operation is a minimum.

In refrigeration, we deal with heat units, and slight losses here and there represent quite a loss at the end of the year. This gross loss must eventually reflect upon the entire equipment, rendering what may have been a satisfied consumer with a satisfactory plant a dissatisfied consumer with an unsatisfactory plant.

The following is a list of manufacturers of ammonia compression machines, which we believe is complete:

"The Hercules," C. A. MacDonald, 301 Monadnock Block, Chicago, Ill.

The Triumph Ice Machine Company, Cincinnati, Ohio.
The F. W. Niebling Company, Norwood, Cincinnati, Ohio.
York Manufacturing Company, York, Pa.
De La Vergne Machine Company, Foot East 138th street, N. Y.
Fred W. Wolf Company, Chicago, Ill.
The Arctic Company, Canton, Ohio.
Frick Company, Waynesboro, Pa.
Larsen Ice Machine Company, Omaha, Neb.
Boland Machinery Company, 209 South Clinton street, Chicago, Ill.
Memphis Machine Works, Memphis, Tenn.
The Brunswick Refrigerating Company, New Brunswick, N. J.
The Automatic Refrigerating Company, Hartford, Conn.

It is our practice not to recommend any particular machine. In answer to inquiries from prospective consumers, we submit a list of manufacturers.

AVERAGE CONDITIONS

The capacity, horse-power of motor, average box temperatures and average hours of operation as noted in Table III, are the results of actual tests of plants in Philadelphia.

Generally speaking, two horse-power must be installed for each ton of refrigerating capacity.

TABLE III.

Business.	Capacity.	H.-P. of Motor.	Average Temp. of Box.	Average Hours to Operate.
Dairy	3 tons	7.5	38	8.0
Grocery	200 lbs.	0.5	34	7.6
Drug	3 tons	Com. 7.5 Pump 1.0	33	Com. 4.75 Pump 15.0
Butcher	3 "	7.5	36	6.0
Residence	500 lbs.	2.0	39	8.5
Saloon	500 "	2.0	40 min. 45 max.	9.0
Restaurant	500 "	2.0	35 min. 45 max.	15 0

The lower the pressure and temperature in the condenser coil and the higher the pressure and temperature in expanding

coil (back pressure), the more economical will be the working of the plant.

The restaurants are using direct expansion
The butchers are all using the brine storage
The dairies use brine circulation
The saloons use brine circulation
The drug stores use sweet water circulation
The grocers use brine storage
The bottlers use brine storage

IN CONCLUSION

By the foregoing tests and conditions it will be noted that the cost of operating the small refrigeration machines by the electric motor at current rates compares favorably with the cost of ice. This must be effected, however, by confining the use of current as nearly as possible to actual required temperature under proper insulated conditions. The advantages from use of the motor-driven machine more than offset the attention required, which, with a good machine, is nominal.

Unfortunately, the owners of small plants have no idea of the conditions of operation, and they are thus rendered helpless to meet this question and secure the best possible method of refrigeration, which involves a minimum first cost with a minimum cost of operation and a maximum service value. This is analogous to our motor problems, and we should be guided accordingly.

The refrigeration question introduces problems distinctly technical, and it is hardly possible to work up a large load through the regular soliciting force, except possibly to interest the prospective consumer, after which the question should be referred to a competent engineer.

In soliciting this class of business, the prospective consumer desires to know the cost of installation and the cost of operation.

The cost of installation depends upon factors that are questions of engineering. The cost of operation depends upon questions of engineering, which are compared with costs of various forms of drives, making it necessary for the solicitor to discuss from an engineering standpoint the relative merits and demerits of different methods of drive.

The course of procedure in handling this class of business is outlined as follows:

Advertising with return postal cards.

Answers referred to refrigerating engineer.

Preliminary visit by engineer for measurement of ice box and conditions.

Calculation of data secured.

The requirements and the cost of operation determined.

Proposal submitted for current.

Mechanical refrigeration relieves the consumer of dependence upon the ice man. He escapes the slop, inconvenience and labor of loading ice, with its consequent financial loss.

Mechanical refrigeration does away with the filth in the ice bunker, resulting from impure ice. The cold air of mechanical refrigeration is comparatively dry, sweet and pure, preventing the possibility of slime and the lodgment of disease germs.

An even temperature is secured, lower than ice will produce, if desired.

The "trimming" loss incidental to the preserving of meats in other refrigerators is entirely avoided. This item alone would save the owner of a butcher shop many times the interest on the cost of installation.

The above conditions would indicate that the central-station managers must become familiar with the practical side of mechanical refrigeration.

I desire to thank the manufacturers for the assistance they have rendered in furnishing cuts.

PRINTED INFORMATION ON REFRIGERATION

Compend of Mechanical Refrigeration, by Siebel.

Ice and Refrigeration, Monthly Journal, Chicago.

Cold Storage, Monthly Journal.

International Library of Technology, published by the International Text Book Company, Scranton.

The American Correspondence Schools, Chicago.

Principles of Artificial Ice Making and Refrigeration, by L. M. Schmidt.

Thermodynamics, Heat Motors and Refrigerating Machines, by De Volsen Wood.

DISCUSSION

Mr. Leon H. Scherck (Birmingham, Ala.): I wish to ask Mr. Meyer a question as regards what is stated on page 155—"About two years ago the Philadelphia Electric Company retained an engineer to solicit this class of business. With the able assistance of the advertising bureau many inquiries were received and contracts closed, the consumer introducing the equipment at his own expense." I should like to know if in securing the business it was found necessary to offer any inducements in the way of guarantees, either by the local companies or by the refrigerating companies, in order to have specially small consumers go to the necessary expense of installing these refrigerating plants. In the various companies with which we are associated we have taken up the question of refrigeration by electricity and have sent some of our local people to make a study of the conditions in different cities. In our situations the conditions for refrigeration by electricity ought to be specially favorable, the properties being located in the middle states and as far south as Texas—places in which ice is required for a large portion of the year—but the difficulty they have met thus far is to get the consumer to buy the apparatus. It is all right if the company will make arrangements to put in a machine and take the consumer's notes for payment, consumer agreeing that if certain conditions are fulfilled he will pay for the plant in a certain length of time. It is much nicer, however, from the central-station standpoint, if business can be obtained otherwise, and I should like to hear from Mr. Meyer if he has been forced in Philadelphia to make any guarantee, or if he has found it necessary to have the companies manufacturing the refrigerating apparatus make guarantees, before the customer was willing to install the apparatus.

Mr. Meyer: I do not believe our company was put to any expense in making the original installations, other than the furnishing of current for probably one or two months. At the time the Philadelphia Electric Company took up the question of refrigerating there was only one refrigerating company that had a very small machine, suitable for the work we anticipated. It, in a number of cases, placed the machine under an arrangement that if certain results were not produced the machines could be removed without expense to the saloon-keeper. In one instance the machine failed to do the work; but that was one of the cases

in which, I believe, had the builders given proper attention to the insulation conditions the plant would have proved satisfactory. I do not know of any instance in which the company has had to make the first expenditure.

MR. W. W. FREEMAN (Brooklyn, N. Y.): A practical difficulty has been experienced in connection with refrigerating apparatus in our territory and I should very much like to know whether it is peculiar to our town or whether it has been at all general. It seemed to us some months ago that there should be considerable business obtained in electrical refrigeration, and, following the plan of Philadelphia, we organized a department to exploit this feature of the business. Within a comparatively short time we found twenty-five or thirty places where refrigerating apparatus could be installed, but we were unable to get the apparatus to put in. We have abandoned our refrigeration department for the simple reason that after orders were secured the refrigerating plants could not be obtained. We are ready to go to work again just as soon as we can get the apparatus. If the fault is ours we want to know it. We found it simply impossible to obtain refrigerating apparatus for the average small place of business in any reasonable length of time. We have come to the conclusion that we can not do any business with refrigerating plants this summer for this reason, and it is the only reason. I should like the experience of other companies on that point, if possible.

MR. FRED. E. MATTHEWS (Hartford, Conn.): Being engaged in the sale of refrigerating apparatus, I am possibly in position to answer that question. In the last year we have had to deal with abnormal conditions which no manufacturer, no matter how extensive his manufacturing facilities, has been able to satisfy. The largest manufacturers of refrigerating machines in the country have in many instances been unable to make deliveries short of ninety days, and some have been in even worse condition. This condition, however, has never before been experienced in the history of refrigeration. As to the question of how this can be remedied, we think it will look after itself in the future. The manufacturers will undoubtedly adopt measures to protect themselves against these abnormal conditions. So far as the customers are concerned, they will probably do as they have always been doing—take a year in which to make up their

minds as to whether they want the apparatus or not, and when they do decide, insist on having it yesterday. Almost all of the small consumers of ice are in that category. They first wait to make sure that the ice crop is going to be a failure, after which they make a rush for the ice-machine man and are surprised to find that they can not get a machine as quickly as they would like.

I want to emphasize one thing regarding the small refrigerating-machine industry, and that is that central-station managers, and even we ourselves, do not realize anywhere near the extent of the field. Every day brings up inquiries for machines to be used in lines we did not know about yesterday, and I think it will continue to be so for years. I do not think we have even touched the small-machine industry yet. We have a small refrigerating machine on exhibition on the pier, which we shall be very glad to show you; but please do not all come at the same time to see it.

Mr. Meyer: Regarding the securing of apparatus, we have met identically the same problem, but I must say we have not ceased to solicit for this business, as we contemplate closing two contracts for supplying current to two 50-ton plants within the next two months. It seems to me that in this refrigerating business this is one of the difficulties we shall encounter. It would probably be within the scope of this organization to confer with manufacturers of equipments and have some clear understanding—that is, let us as central-station men show to the manufacturers what we anticipate in this line of business. There must be an enormous amount of it in the country.

Mr. S. B. Storer (Buffalo, N. Y.): I should like to ask Mr. Meyer if he has made any attempt to use ice machines to fill the "low spots" in his load curve—in other words, to build up the all-day load of a plant—or whether no attention has been given to that part of the business. I am representing a water-power plant and am interested in maintaining a high load factor throughout the twenty-four hours, and should like to hear from members of the association in reference to the way they handle large and small ice plants and see what the general opinion is as to the possibility of their use for this purpose.

Mr. Meyer: We treat the refrigerating problem the same as we do the general power proposition. It is a mistaken idea

that the refrigerating load does not cross the peak. I have purposely included in this paper a table of a test on a restaurant equipment, showing that the machine is operated from twelve o'clock, noon, to approximately nine o'clock at night, and that this condition holds throughout the year; so I do not see how we can safely separate it from the general power proposition unless we stipulate the hours during which the machine must be shut down.

MR. D. F. McGEE (Red Oak, Iowa): We have had some experience with mechanical refrigeration on a small scale. We are operating these machines in butcher shops and in wholesale and retail grocery stores. We find no difficulty in making a contract with these customers to shut down their machines during the peak-load hours of our station when they install brine storage tanks in connection with the direct cooling coils. We are able to make a very low rate under these conditions. It is very satisfactory business for us as well as for our customers.

THE PRESIDENT: We will now pass on to the next paper, *Fuel Economy,* by Mr. J. Henry Hallberg, of New York.

Mr. Hallberg presented the paper, as follows:

FUEL ECONOMY

Since the earliest days of steam production the great aim of engineers has been to devise improved means for the more complete utilization of the heat generated for the purpose of raising steam. It is to this early realization of the great importance of reducing the percentage of loss of heat that the rapid strides in this particular field are due, which have brought about the modern boiler installation, with its water-tube boilers, improved grates, mechanical stokers, economizers and similar appliances.

It appears, however, that at first hardly any attention was paid to the personal element. Hand stoking was thought to be such a simple matter that very little loss or gain could be dependent upon it, and so long as the firemen did their duty by bravely shoveling in coal whenever any one happened to be watching them, no further control was thought necessary.

Certain methods were thus established among the firemen, which to a considerable degree are based on erroneous assumptions, but are nevertheless often accepted by employers. These methods have been only too faithfully adhered to by successive generations, and, notwithstanding the vast improvements that have been made in the construction of the furnaces themselves, are still practised unquestioned by the great majority.

In recent years it has, however, been realized more and more that the methods employed by the average fireman are anything but ideal, and that a great waste of fuel could be avoided if the results of stoking could be improved.

In time great efforts were made, and among the various improvements invented, a prominent position must be allotted to mechanical stokers. There is no doubt that these appliances on the whole handle coal more economically than the average fireman, but they also require attention; and, as they do not eliminate the personal element entirely, even they are *in themselves* no safe guarantee of good results.

These observations, made over and over again in every-day practice, have proved conclusively that what is wanted is a more scientific mode of firing, and a more intelligent working of the

furnaces—no matter what their construction may be—if the best results possible are to be obtained under the prevailing conditions. To achieve this, the first necessity is that these results should be known, not only to every engineer, but also to every fireman.

It does not suffice to take occasional evaporative tests; these do not give a reliable record of the average performance of the furnace, nor do they show for one moment how the men usually work. Only continuous control and records can possibly furnish such information.

It is to-day universally acknowledged by engineers that the most reliable, most minute control of the results of combustion is obtained by means of continuous analysis of the flue gases and by determining the percentage of CO_2 (carbon-dioxide) they contain. Carbon-dioxide is formed by the chemical combination of the carbon—the principal ingredient of the fuel, with the oxygen contained in the atmospheric air admitted into the furnace. To effect the complete combustion of a known quantity of fuel of given quality, a certain amount of atmospheric air is required, and just that amount—no more and no less—should be admitted into the furnace, because the percentage of CO_2 in the flue gases is directly dependent on the quantity of air admitted. It is this percentage of CO_2 which discloses whether or not the proper conditions prevail for such complete combustion.

Theoretically speaking, the presence of 21 per cent of CO_2 in the flue gases would indicate perfect combustion. In furnace practice it is, however, impossible to obtain good results when only the theoretical amount of air (corresponding to the above 21 per cent of CO_2) is supplied. A certain excess of air is required; this excess, however, should not be more than about 35 or 40 per cent over the theoretical amount, and the percentage of CO_2, therefore, that would indicate the best practical results —that is to say, the highest attainable heat from the smallest amount of coal—is about 15 to 16 per cent.

It is a remarkable truth that even the best equipped but uncontrolled furnaces hardly ever show anything like this percentage, in fact, the great majority never reach more than about 7 or 8 per cent, corresponding to about 20 to 21 per cent loss in fuel.

This applies alike to mechanically and to hand-fired fur-

naces. Then there are in addition the great bulk of old type of boilers and furnaces in which the average result is not more than five per cent.

The enormous quantity of fuel thus continually being wasted is vividly revealed by a study of the following table:

When the percentage of CO_2 is 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 per cent.

Then the percentage of loss of fuel as compared with the theoretically lowest possible quantity is: 90, 60, 45, 36, 30, 26, 23, 20, 18, 16, 15, 14, 13, 12 per cent.

Now, it is in the power of every engineer to improve considerably the working results of the particular installation under his care, and to raise it to the highest standard of economy within the possibilities of the particular plant, by means of keeping continuous records of the percentage of CO_2 obtained in the furnaces.

A few days of experiment will determine the exact draft pressure necessary for the highest attainable combustion, and the dampers will be regulated accordingly.

It will be easy to ascertain what method of firing will bring the best results, and what thickness of fire should be maintained. Should there be any flaws or cracks in the brickwork, or "holes in the fire," these will be easily detected and at once remedied. Not infrequently, changes in the design or size of the grate, or improvement in the flues or the chimney suggest themselves, which when carried out are the means of further improvement in the combustion and economy of fuel.

It follows that success now depends only upon the practicability and reliability of the analyzing and recording apparatus, and in this point is perhaps to be found the reason why the apparently simple solution of the problem of fuel economy, as detailed above, has not been generally employed in practice long ago. It was the apparatus that was wanting. To be of any use, this must be designed to continuously and automatically analyze the flue gases and to continuously and automatically record the percentage of CO_2 directly on a diagram, thus forming a continuous and permanent chart, showing the results of combustion at any moment during twenty-four hours. It is further essential that the instrument should be worked without any great expense, and that a minimum amount of attention be required.

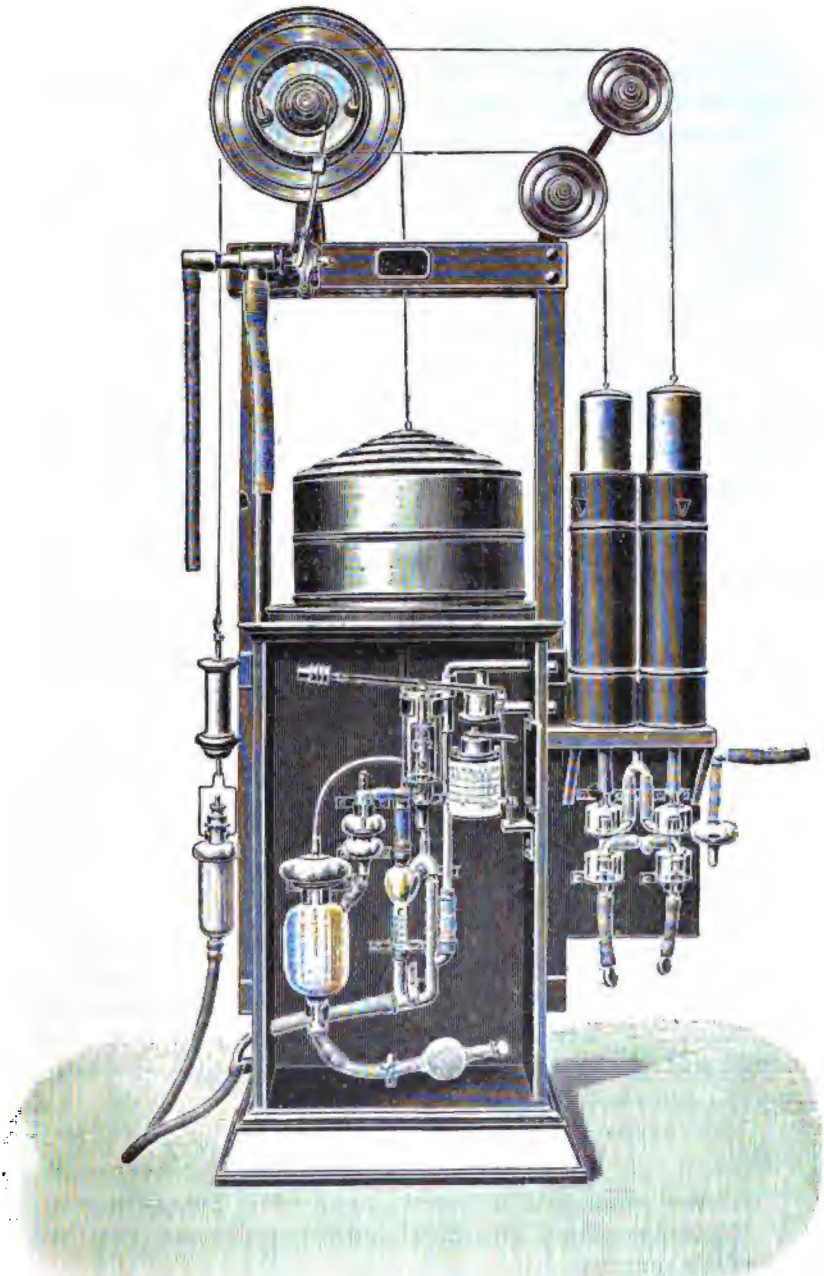


FIG. 1—AUTOMATIC CO_2 RECORDER (COMPLETE READY FOR INSTALLATION AND PIPING)

Several years ago Mr. Arndt of Germany invented and patented an Automatic CO_2 Recorder.

A large number of these recorders have been in practical service abroad during the past four or five years, and in most cases the fuel saving has paid for the recorder in six months' time; in a few boiler plants the recorder paid for itself in a single month.

Some months ago this recorder was imported to this country and one was installed in the largest electric power plant in New York City. The operation of the recorder was so satisfactory that three additional instruments have been ordered. Some large users of boilers in this country have placed their orders within the past few months, and several recorders are now installed and are giving excellent service.

The accompanying illustrations show the Automatic CO_2 Recorder referred to, and the following general description may be of interest:

The working of the recorder is based on the well-known fact that a solution of caustic potash absorbs CO_2 gas (carbonic acid gas).

The Recorder consists of:

Air Motor.

Gas Pumps.

Analyzing and Recording Apparatus.

AIR MOTOR

The motor consists of tank, bell and fittings. The interior of the bell is connected with the chimney by means of a tube.

The draft in the chimney creates a vacuum under the bell, which is pressed into the tank by atmospheric pressure. Air is then admitted into the bell by the automatic action of a valve, and the bell rises again.

This motion recurs about every five minutes, and it is utilized to raise and lower a bottle filled with glycerine, and to drive a pair of specially-designed pumps, which pump flue gases through a tube from the chimney through the analyzing and recording apparatus.

So long as there is any draft in the chimney the motor

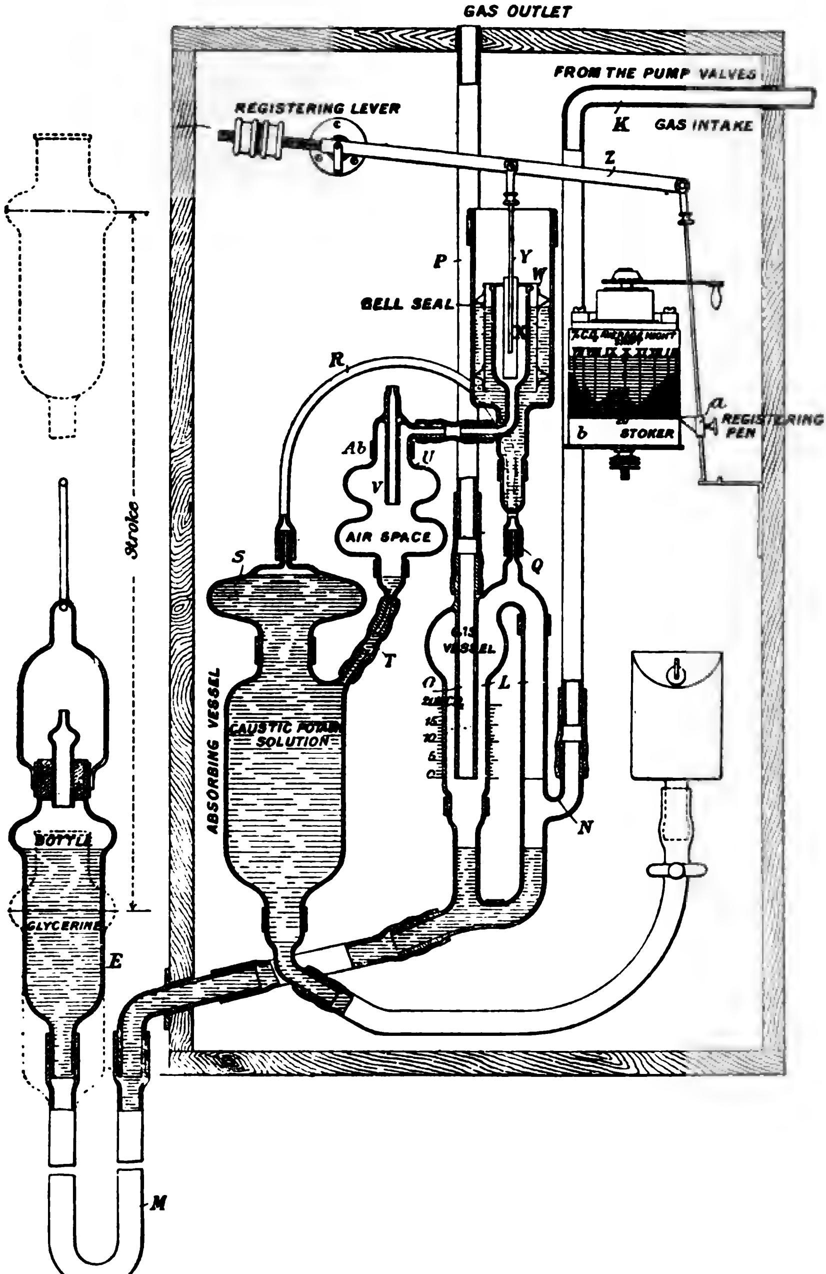


Fig. 2—Diagrammatic View of the Analyzing and Recording Apparatus

will work without any further aid or supervision. A chimney draft of half an inch on water is quite sufficient for driving the motor.

GAS PUMPS

The gas pumps consist of two cylinders, which dip into oil tanks and rise and fall alternately, drawing flue gases from the chimney, and forcing them through the recorder. As the pumps deliver about twenty times the volume of gas required for an analysis, the same gas is never analyzed over again.

ANALYZING AND RECORDING APPARATUS

The analyzing and recording apparatus consists in the main of a glass tube, which serves as a measure to bottle up 100 cubic centimetres of gases, of a bottle containing a solution of caustic potash, which absorbs the CO_2 gas, and of a pen which records the percentage of CO_2 gas ascertained.

The pen draws ink lines on a clock-driven chart in the usual way.

OPERATION

The gases that are to be analyzed are forced into the recording-cabinet by the gas pumps through the tube *K*, which is shown in Figure 2.

Bottle *E* is periodically raised and lowered through the action of the air-motor and is in communication with the system of measuring tubes *L* by means of a flexible pipe, *M*. The bottle *E* is filled with a mixture of glycerine and water in the proportion of one part of the former to three of the latter; and when the bottle rises, the liquid in the tubes *L* rises at the same time, and when it reaches the point *N* it closes the inlet for the gas from *K*. Contained in *L* is an inner gas-escape tube, *O*, which is connected with the atmosphere by the pipe *P*. When the liquid reaches the bottom end of the tube *O*, exactly 100 cubic centimetres of flue gases are contained in the glass vessel *L*.

As the bottle *E* rises farther the gases in the vessel *L* are gradually forced through the tube *R* into the vessel *S*, which contains a solution of caustic potash of 1.27 specific gravity. The whole of the 100 cubic centimetres of the gases have been forced over when the liquid in *L* reaches the mark *Q*, this being the point at which the air-motor reverses.

The moment the gases come in contact with the caustic potash in the vessel *S* the CO_2 is absorbed. The pressure of the remaining gases displaces the potash in *S* and forces it up the tube *T* into the air-vessel *U*. When the potash reaches the bottom of the tube *V*, which connects *U* with the atmosphere, a certain quantity of air is bottled up in the space above.. When the potash has risen to the bottom of the tube *V*, it has driven sixty cubic centimetres of air at atmospheric pressure out through the tube *V*; but on the potash rising further, it compresses the air in the upper part of the vessel *U* and raises the bell *W*, which floats on a glycerine seal, clearly shown in Figure 2. In the bell *W* is inserted an inner tube, *X*, which is closed at the lower end. To raise *W* to the point where the lower end of *X* touches the rod *Y*, twenty cubic centimetres of air are taken up, and the remaining twenty cubic centimetres (making up the 100 cubic centimetres) serve to raise the registering lever *Z*. To this lever there is attached the pan, *a*, which draws lines on the chart carried on the drum *b*.

The chart is calibrated in per cents from 1 to 20, and the time is marked on it. For every per cent of CO_2 absorbed, one cubic centimetre of air less is displaced, and the registering lever is made to rise one per cent less on the chart. It will therefore be seen that when there is no CO_2 present the pen will rise to the top of the chart.

IN GENERAL

It is advisable to have one recorder for each furnace. Where it is, however, desired to test several furnaces by one recorder only, the recorder may be connected with each furnace by means of a system of tubes, and the furnace to be tested is to be switched on. As a matter of fact, one recorder may take care of four to six furnaces in actual practice, where the firemen are accustomed to work by the recorder.

The recorder occupies about four by three feet of floor space and stands six feet high.

The chart must be changed and the clock wound each day.

The caustic potash solution must be renewed every week when working night and day shifts, or every fortnight when working day shifts only.

The caustic potash solution is made as follows:

Take 395 parts by weight of caustic potash
875 parts by weight of distilled water
1270 parts by weight of caustic potash
Solution of 1.27 specific gravity.

The cost of the solution required for one filling is about 30 cents.

Metal valves, and other parts requiring fitting and care, are not required for this recorder, as all inlets and outlets are opened and closed by means of glycerine, water and oil seals.

CONCLUSION

Where the load on the boilers fluctuates, as it will in lighting and railway plants, the recorder instructs the fireman how to handle the dampers.

The use of the CO_2 recorder enables the manager to get better service from his firemen, and in case of a strike it is possible to get fair results from inexperienced operators.

The distribution of premiums to the fireman who maintains the highest CO_2 record will also suggest itself with the introduction of this recorder.

The automatic recorder may also be used in connection with gas-fired boiler installations, and several recorders are working in conjunction with producer-gas plants.

DISCUSSION

MR. G. E. CLAFLIN (Boston): I ask what is the cost of this recorder? In a large plant it might involve considerable investment, although it might be well worth it.

MR. HALLBERG: The recorder as illustrated is imported from England and costs $375 (including duty), free on board docks, New York. The first cost may seem high, but there is no 200-hp boiler plant operating 10 hours per day that can not afford to install one CO_2 recorder.

MR. LUTHER R. NASH (Savannah): There is no doubt as to the great advantage to be obtained by analysis of flue gases, but I think Mr. Hallberg is perhaps mistaken when he states that a continuous record is the only thing that is of any use. There have been manually-operated devices on the market for many years that can be used for analyzing flue gases. The Orsat

type of apparatus, which has recently been simplified, is compact, inexpensive and readily adapted to such purposes. It can be attached to boiler or stack and the percentage of CO_2 determined at will by the engineer. The probable reason why this apparatus has not been used more is the fact that prior to the introduction of the recording apparatus of the Ados type the great advantages of flue-gas analyses were unknown. The value of the Orsat type of apparatus is of course limited by the number of tests that the station operating force may find it possible or convenient to make, and the errors to be expected in making the analysis itself.

So far as I know, the economy that can be obtained by systematically using a manually-operated device as compared with the saving from a continually-operating device has not been determined. In my own case, after carefully looking into the question of flue-gas analysis, I have decided to experiment with the Orsat type of apparatus with the idea of determining the adjustment of drafts and dampers that is necessary under different conditions of load to give the proper percentage of CO_2, and, as a regular thing, to watch the drafts and dampers rather than the analyzing device, the latter being used from time to time as the general load conditions, fuel, and so forth, vary. If it is found by frequent analyses that the firemen are not giving proper attention to their draft, and it becomes evident that a continuous record of CO_2 would result in an increased percentage of saving in fuel, it would be a very easy matter to figure out whether or not a recording outfit would pay for itself. Without in any way questioning the advantages of a continuous record, many small plants would hesitate at an expenditure of $400 for it if they could approach its results by an expenditure of one-tenth that amount with the systematic use of a simpler apparatus.

MR. HALLBERG: Hand-operated instruments of any kind should be avoided in a power plant whenever possible. There is great reason why the manager and superintendent should know what takes place in the furnace, where the losses are greater than in any other part of the plant. This is the vital spot in the central-station system, and he can well afford a reasonable investment to know at all times what is going on in the furnaces and how the firemen are doing their work when he is not

around. A hand-operated machine will not give a continuous record, and the conditions may be exceptionally favorable at the time the analysis is being made, which would, of course, make the record of little value. Furthermore, the hand machine requires the attention of some intelligent person, whose time is worth something, and it seems out of the question to make analyses by hand at the rate of twelve times per hour, as the expense of this method would be prohibitive. I believe it is important that the record of flue-gas analyses should be continuous, or practically so, as only by this means can the trouble, if there be such, be detected. The continuous record will also give the manager and superintendent means for rating their firemen. It may be interesting to note that in several places where the automatic CO_2 recorder has been installed, firemen who have not been considered experts have produced the best results, to the surprise of the management. The recorder is very sensitive to any change in the draft conditions of the furnace, and the lines drawn on the chart are of great assistance to the fireman in that within five minutes after he has made a change in the thickness of his fire, drafts or the like, he can see for himself whether the change was in the right or in the wrong direction and can, of course, be governed accordingly, thereby in almost every instance increasing the economy of the plant to a considerable extent. A saving of from 10 to 20 per cent can readily be effected by the use of some form of automatic CO_2 recorder, and it seems to me that $400 is not an excessive amount to spend in order to make such saving and, incidentally, to know what you are doing and be able to keep a check on the firemen.

MR. A. J. CAMPBELL (New London, Conn.): There is one statement in this paper to which I think a slight exception might be taken. On page 182 is given the percentage of loss due to the increasing, or, rather, decreasing, percentage of CO_2, showing that the percentage of CO_2 decreases directly with the increased proportion of air. I believe that is theoretically true, but in practical work I do not think it always obtains. In one of the books on boiler economy—I think it is Kent's, or it may be Snow's—there is a table showing the results of some very interesting experiments in which the percentage of CO_2 was determined very carefully with varying percentages of air, and these

experiments showed quite conclusively that these theoretical relations do not hold in practice. The general fact does hold, however, that as you get an excess of air you get a decrease in efficiency.

I think, also, in reference to this particular machine or instrument, that it is somewhat incorrect to say that it records continuously, for if I am not mistaken it produces a record only once in five or seven minutes. I think the value of a recording instrument is very great, and I do believe it will save money by enabling a manager, or any one in charge of a plant, to know what his firemen are doing, but I question whether it will work out in practice exactly as Mr. Hallberg puts it.

THE PRESIDENT: We will now have the paper on *Electric Heating and the Residence Customer,* by Mr. James I. Ayer, of Boston.

MR. AYER: The paper I am about to read, as it states, goes over old ground somewhat on the lines of papers read in previous years. The excuse for this is the result of answers to inquiries that were sent out asking you for information in regard to the development during the past year over the previous year. Last year we tabulated the answers to the questions and got certain results which showed comparatively small experience with electric-heating apparatus. Notwithstanding the fact that we all know there has been a much wider application of electric heating in the last year than in any previous year, the answers indicated that it had gone the other way. In other words, the replies as sent are absolutely valueless on which to base statistics, and many of them have apparently been made with little thought; certainly, many of the responses were made out without any sort of investigation of the real conditions, and a great many show that the managers are not in touch with the developments in their own towns. I have the replies tabulated and in shape to quote, but the effect would be misleading, and instead I offer this paper, which is in the nature of an appeal to you to go at this business in its smaller details.

Mr. Ayer then presented the following paper:

ELECTRIC HEATING AND THE RESIDENCE CUSTOMER

The subject of electric heating, attracting as it is so much consideration to-day, offers little that is new to present to this audience in the way of additional development in the line of new appliances or new applications. This is not surprising when the past is considered, but how few realize the past of this industry, is only appreciated by those who have been identified with its creation for a considerable period.

The first few years of development caused every possible application to be investigated, resulting in great variety of articles of common use, requiring heat, being arranged for electric heat—many of which are catalogued, and many have been set aside as being in advance of the times, though later on they will be found practical.

At former meetings you have had papers setting forth the advantages of electric heating which told the story of its usefulness, and to-day there is but little more to be said without going over the same ground, but because of the greatly increased interest in the subject it seems desirable to report upon it.

That there is an important almost untouched field for electric heating is now broadly recognized. How important it is and how advantageous to develop is, I think, but little understood. Its character makes it largely a day load, and while it is of much value in its application in business establishments and factories, its most important field to the central station is with the residence customer.

The residence customer to-day pays the highest rate. To reduce this rate is most essential, for nothing goes further to check popular prejudice than personal consideration of the individual, and a reduction of rates to residence customers reaches a man in his home. Electric lights are used in the average dwelling because of their convenience and other well-known virtues partly, but largely to be "up to date." It costs money to be up

to date in most things, and if it costs a good deal more for the new than for the old, we kick. If it happens that a public-service corporation is supplying the new, they have a common enemy to kick, hence much of the trouble with which you are all familiar. The residence customer demands the service, but can not appreciate that it is the most expensive you give, and if you explain, he thinks you should find a way to cheapen it, or average your costs and reduce his rates. Human nature doesn't believe in paying "something for nothing," and your minimum charge bill to him is paying "something for nothing." He does not understand that the transformer loss goes merrily on at your expense, though he uses no light, at the rate of four or five dollars per year, and involves additional charges of nearly as much more, all directly created for his service, which would end if his service were discontinued. These facts have no influence with him. He only knows that the cost of his service is high by comparison with other, though less satisfactory, methods. This situation, I think, is fully realized, and it is of vital importance at this time, with the public interest so much centered on corporations, that every means at your command be put forth to put you in closer touch with your customers and thereby let them realize that your corporation is a business enterprise, managed by their neighbors, on the same general lines as all other honest, progressive business concerns in the community.

Electric heating offers an opportunity to quickly get in closer relation with more people in an effective way than any other means at your command, and if this be taken advantage of to the limit more will be done to give the people a proper point of view on public ownership than will volumes of statistics. By proper effort and systematic work persistently and continuously carried out, you can secure the introduction of electric-heating devices in every home you serve.

The methods that may be used are numerous, and from experience we can with confidence make some definite statements.

The advertising methods are numerous in the way of using printer's ink, and much valuable and effective work is being done in this line, and it is understood that no effort to extend any business can have any measure of success without its liberal use. The space devoted to methods of advertising in the electrical

press gives convincing evidence of an extraordinary interest in and an exposition of what is being done.

With an appreciation of the situation it is with some diffidence that I presume to outline a general plan for the average station so far as it relates to a method of extending the use of electric heating and other household devices using electricity.

It has been well settled that more goods of any kind can be sold by personal presentation, and this is, in my opinion, the only way to get the largest return and at the least cost. In all cases it is the only way to get the best results.

For the solicitor, use a customers' list for meter-readers' routes, and make a card catalogue divided into sections, and have circulars, or a typewritten letter with circulars, sent a few days in advance, announcing his proposed call and explaining the object. On each card a record can be kept which will be permanently valuable, as it will show when and what articles have been placed, to guide you in future efforts.

It is necessary to send out articles and leave them for trial after explaining fully how to put them in operation and how they should be cared for, as well as to leave complete printed instructions which manufacturers usually send with each article. The period of time an article should be left will be governed somewhat by the character of the device, but such an article as a flat-iron had better be left thirty days, that ample opportunity may be given to appreciate it fully. In the first instance of offering electric heaters it is better to allow enough time for trial to insure their being thoroughly tested, and to note the effect, if any, of its use on their bill.

Customers should be preferably called on at the expiration of a trial period, to learn their conclusions. This is better than leaving or sending them a blank to sign, requesting you to send for the article or send a bill, as the case may be, because it is frequently the case that further interest has been developed and other articles are wanted.

If your office is centrally located, on the ground floor, and of course it should be, you should have arranged on shelves behind glass, and in the show window, protected in the same manner, an assortment of samples and a few of the popular small articles as stock, so that if a customer is interested he can be supplied at once.

For newspaper advertising, small advertisements frequently changed but constantly maintained are to be preferred, rather than occasional large ones, and newspaper advertising is desirable, though not to be substituted for the solicitor. For more extended methods in advertising, by circulars or otherwise with printer's ink, we will not pretend to guide you.

Exhibitions at food fairs and similar entertainments always prove to be leading attractions and in that way do advertising, but direct results are usually few, and indirect results are difficult to estimate; considering the expense and attention required, it would seem better generally to seek other methods. If it can be arranged, it is undoubtedly a good practice to invite your customers to a practical demonstration of the usefulness of electric heating and serve a light lunch, part or all of which should be cooked by the demonstrator.

The universal use of smoothing irons for many demands outside of the laundry makes this an ideal article for first introducing electric heaters. The success that has followed systematic efforts with this article is too well known to need further argument for its selection for such purposes. Thousands are used about the house, other than for laundry work, and for such purposes the cost of operation is but a trifle. For laundry use they are required from three to five hours per week, costing from 15 to, at most, 50 cents per week; the latter being for the longest period at a 20-cent rate. It is fair to say that at the average rate the average family ironing can be done at from $1.00 to $1.25 per month. With such results your customers will use laundry irons. If they do, they will not kick on minimum charge bills, because they will appreciate they get something for their money.

Because of the quick appreciation of an electric iron you will be called on for other appliances, and by carefully keeping up your card index your solicitor can be kept busy, as the demands from some will suggest what to push with others.

Using the flat-iron as an opening wedge, you will do well to follow with circulars or folders describing such articles as water-cups which will furnish a pint of boiling water in seven or eight minutes in the smaller size, or a quart in a larger size in ten minutes. Either will supply enough for a cup of tea in three or four minutes, and for shaving in less time. These

articles are invaluable in the sick-room, and for use in hundreds of ways. Improvements in these devices prevent their burning out or overheating in the event of boiling dry. This result is obtained by the circuit being broken automatically if the temperature rises a few degrees above the boiling point.

An electric heating pad can always be placed in a home where there is use for a hot-water bottle. Its superior merit is immediately appreciated on the briefest investigation. Aside from its usefulness in illness, it is much used by the aged as a foot-warmer. A naval officer told me he had many nights walked the bridge with a pad under his coat, comfortable in bitter weather, in spite of side remarks about "a monkey on a string."

The nursery milk-warmer performs its work by electricity more uniformly and perfectly than is possible with any other method and in a shorter time. An important feature is that the time required to heat it throughout to an even temperature is less than three minutes, making the period so short after the demand is made that peace is certain. Its operation and sanitary character produce universal commendation from physicians. These devices are furnished with a socket plug arranged to receive the lamp which it displaces in the fixture, which is lighted when current is on the milk-warmer.

Electric curling-iron heaters are welcomed in many homes.

For light cooking and the dining-room there are many useful articles.

The chafing-dish has many accomplishments to its credit. It can perform nearly all the operations of cooking required in homes, but of course in some cases not on the same scale as to quantity, and only one operation at a time, yet its possibilities are limitless when electrically heated. It can bake, boil, fry, stew and toast; is under perfect control, and always performs the same under like conditions, because its heat supply is a known quantity. It is a simple matter to cook and serve a good American breakfast for three, of a cooked cereal, eggs poached, boiled, fried, or scrambled, with toast, in thirty minutes with a chafing-dish at the cost of 250 watts, and coffee can be made for 100 watts more; a total of from three to four cents at the average residence rates. The stove that operates the chafing-dish makes with a kettle a most desirable combination for the tea-table,

and with a coffee percolator in place of the kettle, meets the requirements of the breakfast table.

Chafing-dishes, teakettles and coffee-urns can be had with heaters attached or separate in a variety of grades and designs, and there is no other method so safe, simple, or cheap for performing similar service in the dining-room. The cost for current for performing any single operation with any of these devices is more often one cent or less than more, and never exceeds three or four cents.

For equally useful devices performing much the same work and more, in the dining-room or kitchen, we must remember that the water-cups previously mentioned come in as a part of the list, because they can be used for making coffee or tea, or boiling of any sort. In one case I know of they are used for cooking French-fried potatoes. This type of heater is also made to form a combination of double boiler or cereal cooker, egg-boiler, steamer, as well as a plain boiler.

Disc-heaters, or stoves with utensils, such as saucepans, teakettles, coffee-pots, cereal-cookers, vegetable-boilers and the like, enable the housewife with, say, two stoves and two or three utensils to do all the necessary cooking for light meals, in the dining-room if she pleases, within the limits of cost previously mentioned.

Realizing these facts, you must know that, to broadly extend their use, it only remains for your customers to know that they can do these things. I have on several previous occasions made similar statements and some of you have profited by them, but many have not. Some of you say they are drawbacks; that you have tried electric heaters and they are too slow; that you can not boil a pan of water in half a day, and so forth. To such, it did not occur that a 200-watt stove was hardly the proper size for a one-gallon open pan.

Within a week I have received a complaint that a stove purchased was worthless because it would not heat a glue-pot, which investigation developed contained upward of one gallon of water and glue, and the stove was one made for dentist's use to keep a glass of water warm.

Stoves or disc-heaters should always be supplied with utensils made for them, of suitable proportions and with perfectly flat bottoms.

The above illustrations and explanations are given to remind you of the necessity for learning about electric heaters; their limitations, as well as their good qualities, and the difference between temperature and heat. The difference between the application of electric heat and other sources of heat is not difficult for any one to understand, and that quickly, but there is a difference, and for best results it must be understood. Imagine how complicated the operation of the various gas appliances would be to one who had never seen them. If they should blow it out, how would a gas range appeal to them?

The importance of thoroughly acquainting yourself with each different item by carefully reading the manufacturer's instructions and explanation, then having them put in operation under the working conditions they are designed for, is essential to those of you who propose to place them with your customers, and can not be too much emphasized. Take all of the articles into your own homes and give your solicitors some similar opportunity, and you will get results.

The popular articles I have referred to are what you should concentrate your efforts on until material results are accomplished; but during such period you will have demands for cooking outfits, kitchenettes, or ranges for all the kitchen requirements, as well as water-boilers for the kitchen, heaters for bath water, and radiators, all of which you will occasionally find opportunity to place to advantage.

For general cooking, there are available individual cooking devices in all sizes required for the largest household; also ovens, plate-warmers, broilers, griddles, waffle-irons, frying-kettles, and so forth.

Demands for general cooking will be to fill the place now occupied by gas stoves, which, except in apartment houses, are largely summer workers. Considering for the present those cases where the principal use is in summer, it is customary when using gas stoves to operate the coal range one or two days each week for supplying hot water for washing and the bath, and of course cooking at the same time; this reduces in many cases the demand for service to perhaps six days each week; and in considering the subject the probable practice should be an element.

Experience has shown from a great variety of sources that

the number of watts per meal per person may safely be taken at 300, or 900 watts per day per person. If, however, we allow one kilowatt-hour per person, we have 30 kilowatt-hours for a month, which at a five-cent rate is $1.50, or for a family of four $6.00 per month; or at a three-cent rate for the same family, $3.60 per month. While these rates are absurdly low to-day for lighting rates in residences, there are many cases where the service may be given from separate service wires at a satisfactory profit.

By careful comparison it has been determined that, in cooking, an equivalent cost for $1.00 gas is two and one-half cents per kilowatt-hour, and while electric cooking is widely practical at a higher rate, it will demand from five to three-cent rates to make it an important competitor with gas. Gas, however, occupied a broad field at a much higher price than coal, due to its advantages, and electric methods make it possible for you to secure equal results because of the many advantages possessed by the newer method over the old.

For heating the general water supply, a kitchen boiler of the usual type is used, varying in capacity from 10 to 30 gallons, and supplied preferably with a heater contained in the boiler, of a maximum of 2000 watts, which may be reduced to 1000 or 500 watts by a controlling switch. Such a boiler should be jacketed with ordinary pipe covering, and with care is not necessarily an excessively expensive luxury. A 10-gallon boiler can be heated to 150 degrees Fahrenheit with approximately 2.5 kilowatts, which will answer a very considerable demand throughout the day from a jacketed boiler of that capacity.

For bath water, heaters are supplied to place in the tub, and those with 2000 watts capacity are frequently satisfactory to those who understand in advance that it requires 2000 watts for an hour to raise 20 gallons of water through 40 degrees Fahrenheit.

Radiators for occasional use in bedrooms for short periods are practical and useful, but should have a capacity of not less than 1000 or 1200 watts to be at all effective, and, except in the case of small rooms, they should be larger.

For heating the bathroom, many radiators are sold which, to be effective quickly, should have 2000 watts capacity. Of this size, if turned on for fifteen or twenty minutes they fully accomplish their purpose, and are not expensive to the owner.

The instantaneous hot-water heater to be practical requires that current supply of 3000 watts and more be available. While for small quantities the cost of operation is not excessive, the service demand is undesirable and it is expensive to install, and as small water-heaters are so much more simple and easy to supply, they meet the demand for small requirements.

In referring to water heating and radiators, I appreciate that the field in any community, with rare exceptions, is very limited, yet the sale of these devices reaches a very considerable sum annually, and is daily increasing.

The service for a family kitchen for the average family for cooking should have a capacity of about 3000 watts, and if a kitchen boiler, bath-water heater, or bathroom radiator is to be included, a double-throw switch can be installed in the kitchen or other convenient place, so connected as to throw off the boiler, radiator or bath circuit when the cooking circuit is required, and to avoid the necessity of extra large service capacity which would otherwise be necessary.

This also suggests a method of limiting the hours for cooking service to a period when lights are not required, but it has objections, although it is practical.

The cost for heating water to different temperatures at different rates is here given, which best tells what is required in current supply for a given result in quantity, temperature and time as well:

INITIAL TEMPERATURE OF WATER, 60 DEGREES FAHRENHEIT
EFFICIENCY OF APPARATUS, 85 PER CENT

ONE PINT

Total Temperature	Watts Used for 5m.	10m.	20m.	1 Hour	Cost in Cents with Current at 3c.	5c.	10c.	20c.
100° F.....	164	82	41.04	13.68	.041	.068	.136	.272
150°	372	186	93	31	.093	.155	.31	.62
175°	468	234	117	39	.117	.195	.39	.78
200°	576	288	144	48	.144	.24	.48	.96
212°	624	312	156	52	.156	.26	.52	1.04

ONE QUART

Total Temperature	Watts Used for 5m.	10m.	20m.	1 Hour	Cost in Cents with Current at 3c.	5c.	10c.	20c.
100°	324	162	81	27	.08	.136	.272	.544
150°	744	372	186	62	.186	.31	.62	1.24
175	936	468	234	78	.234	.39	.78	1.56
200°	1152	576	288	96	.288	.48	.96	1.92
212°	1248	624	312	104	.312	.52	1.04	2.08

ONE GALLON

Total Temperature	Watts Used for 5m.	10m.	20m.	1 Hour	Cost in Cents with Current at 3c.	5c.	10c.	20c.
100°	1296	648	324	108	.32	.544	1.088	2.17
150°	2976	1488	744	248	.74	1.24	2.48	4.96
175°	3744	1872	936	312	.94	1.56	3.12	6.24
200°	4608	2304	1152	384	1.15	1.92	3.84	7.68
212°	4992	2496	1248	416	1.25	2.08	4.16	8.32

My judgment is that the policy to pursue is to press personally the sale of small household devices constantly, without complicating the situation by trying to interest your customers with the larger problems until from experience with the smaller they have become prepared for further ventures. During such a period you should gain practical experience in the larger problems in your own home, and you will find customers who will insist on complete equipments at such rates as you can make, and from these sources you can gain the additional knowledge to govern your future policy. The small devices will earn from $1.00 to $2.00 per month, which will cover present transformer losses and leave a profit, and the satisfaction of your customers with their use, coupled with the advantages gained by your personal interest in them as shown by such efforts to extend the service, will more than justify all your efforts.

When business depression comes, one may cut off his electric signs but not likely a house service, which provides many conveniences besides his light. Those of you who have followed the policy outlined can, I am sure, endorse my suggestions. That there is a large army of managers who have only begun to consider this subject seriously is my excuse for going over much the same ground as I did two years ago in a paper on this subject at the Boston convention.

I have confined my remarks to the development of electric heating with residence customers, not with the thought that you should neglect the fertile field among manufacturers and merchants, but to impress on you the importance of the small consumer, believing it to be the most direct way of creating a widespread interest in a branch of electrical development which has a possible application with practically every customer on your lines. If it is practical in his home it will suggest its use in his business, and his demands can be met.

DISCUSSION

The President: We should like Mr. Loewenthal to open the discussion on this paper.

Mr. Max Loewenthal (New York City): It is very kind of your president to give me the opportunity to say a few words on electric heating—that is, I feel that he is kind to me. It may be due to the fact that I have been engaged in electric-heating work for a large number of years, or perhaps—and more likely —because he knows that any one engaged in electric-heating work wants to get rid of all the gas that is in him.

I want to congratulate the association on having presented to it this splendid paper by one whom I consider the dean of the electric-heating industry. To me this paper of Mr. Ayer's appeals as a very sane argument in behalf of the subject. It is not merely a compilation of tables, which are very frequently based on laboratory experiments and are not always applicable to everyday service and conditions, for there are few men who are able to discriminate between data based on theory and on fact, on account of lack of experience along these lines.

I believe, furthermore, that we have passed what may be called the "fad and fancy" period of electric heating. We have now established the industry on sound principles, and an intelligent argument of this kind is therefore extremely helpful. While Mr. Ayer, perhaps rightly, states that very little new can be presented along the lines of new appliances and new applications, considerable new material is presented among the advertising exhibits made by the committee on progress, and this tends to prove that you are thinking along the lines pointed out by Mr. Martin this morning—namely, looking out for the outside interests of your plant—that is, your customers—and not concerning yourselves only with inside affairs. You are taking a greater interest in the evident needs and wants of your customers, and that is bound to work for your benefit.

Regardless of this, however, the development and application of electric heating has been slow and is still very limited. We who have watched its growth will not be satisfied until we have a "wired house" instead of a "piped house." When you consider that only 44 per cent of the population of 5000 cities in the United States have access to the electric current, and then think for a moment how small a percentage of the 44 per cent

actually use it, you will probably second my statement that the use of current may be said to be extremely limited. There are two reasons for this—one is that the public is not educated up to the uses and conveniences of electrical appliances, and the other is that it is prejudiced against all things electrical. It is for you to depolarize the mind of the public in this regard. You are to saturate it with the domestic application of electricity. This is an *electro-domestic* problem—if that word may now be coined.

The main reason for this limited development, however, is the shortsightedness on the part of the central-station man. Having managed electric-heating campaigns for a number of central stations, I may be pardoned for this accusation. He frequently believes that his work is well and completely done after he has generated and transmitted his current. That is not true. He has to, whether he wants to or not, become a merchant, and though he may scorn and be unwilling to use them, he must employ the tools of a salesman. This is a mercantile proposition, and I should advise every one of you to install a mental transformer which will transform you for the time being from an engineer or old-time central-station manager to a modern electric-current merchant. You must do several things—you must see that the people are made acquainted with electric heating and other electro-domestic appliances. Not by simply showing them, because showing or talking electric-heating devices never sells them; they have to be demonstrated, for people want to see them work. Do not make extravagant statements. They have been made and are being made, but people do not want them, they want actual facts. You may say there are no facts. If you have not obtained them before this you may obtain them easily, as was stated in the paper, by installing in your own home or in the home of some one connected with your company some of the appliances or an entire cooking outfit. First of all, you must have confidence, absolute confidence, and must inspire your employees with the same confidence, not only in the future of electric heating, but in the efficiency and utility of the apparatus and the fact that the people actually need and want it. Be assured that it is not price that holds the industry back, but lack of enterprise; it is not solicitation so much as education that is needed.

We have seen installed during the last year a number of complete electric kitchens, or kitchenettes, as they have been

called. Every one of these has been satisfactory. I have collected statistics and I find that all the ironing and cooking for a family of three or four persons can be done for about $6.00 or $7.00 per month at a five-cent rate. That covers in one case a period of two years, and I have here a photograph of 24 bills, the average of which is $6.69 at a five-cent rate.

I suggest, furthermore, that you co-operate with builders and architects, for several examples have convinced us that the houses in the future may be built differently from the houses in the past by not excavating the entire foundation, but only that part in which the furnace and coal to operate it are located. Thus, by excavating only a part of the cellar, leaving out entirely the coal range and the gas stove, putting no gas pipes in the house (and you would not need any chimney for the coal range), the saving effected will amply pay for electric-heating circuits—and no modern house should be without electric-heating circuits in addition to electric-lighting circuits and separate therefrom—and will also pay for the entire electric kitchen equipment. This is a fact, and we have further data on the subject, which will soon be published.

I want to point out, furthermore, the necessity of telling your prospective customers for heating apparatus that they must not put those devices that take more than two or three amperes, at 110 volts, on lamp sockets with keys, because they are almost certain to do damage to the key and you are apt to make a dissatisfied customer.

On account of the length of time I have spoken, for which I ask your pardon, I will not enter into a detailed discussion of this paper, for everything expressed therein coincides fully with what I have found to be the case. There is one thing that is not mentioned in regard to proper canvassing, namely, that in addition to exhibitions and the putting out of irons and utensils on trial one of the best methods has been the giving of lectures on the subject. There are several persons, mostly women, trained in the art at the present time, and they are making a success wherever they lecture to the public, making them acquainted with the devices. Do not ask the people whether they want you to put heating apparatus in their homes or not—put it there. Send out an automobile, operated by a young man, accompanied by a woman canvasser, and filled with current-

consuming devices. Let it go from house to house, if necessary; let the woman take two or three articles into the house with her, leave one or more in the house, and you will find that perhaps 75 per cent of these cases will "stick."

If this heating proposition appears to you as unworthy of your efforts, just think for a moment that it is very much like the unruly boy on whom the parents did not want to spend money because he was not worthy of it, and later in life that very bad boy turned out to be a very good boy and added materially to the support of his parents.

THE PRESIDENT: Is Mr. Hillman, of the General Electric Company, or some representative of the heating department, here? If so, we shall be glad to hear from him, or from any one else who wishes to speak on this subject.

MR. E. F. McCABE (Lewiston, Pa.): I wish to take some exception to the remark of the last speaker, in which he said that the shortsightedness or old-fogyism of the central-station manager kept the heating apparatus from coming forward. I have found, in talking with many, that the trouble has been with the heating apparatus itself. It is not the station manager that is slow, but the apparatus itself.

MR. H. L. WALLAU (Cleveland, Ohio): There is one thing that we have to contend with in Cleveland, and that is natural gas at 30 cents per 1000 cubic feet. The cost of getting up meals for a small family by electricity at the prices here given would be $4.50 per month. I can put natural gas in a house, cook the meals and heat the water for bathing, washing of clothes, and so forth, for 90 cents a month and with artificial at 75 cents per 1000 for $2.50 per month. If we want to put electric-heating devices in the houses of that city, which for the most part are already equipped either with natural or artificial gas stoves, we have to contend with the original investment that has been put into the stoves, and it makes a hard proposition in the case of the average family, which can heat, cook and wash for a dollar a month, to ask them to make an investment in an electric equipment and then say that it costs $6.00 or $10 per month to run it. The domestic field in such a case is limited to emergency cooking devices, small irons, and similar apparatus.

MR. AYER: I want to say just a word. The last two speakers emphasized the argument I tried to give all the way through.

They have told their troubles. As a matter of fact, Cleveland is a very satisfactory market, and I think the representatives of the company will bear me out that they are meeting with considerable success in placing small articles. I want to impress upon you not to go after big things, such as general electrical cooking—to sell electric ranges against gas ranges—until you know all about it yourself. In the meantime, sell the things you can sell, which will put you next to your customers. Provide a half-dozen articles of use and comfort about the houses that are supplied to-day only with service for lighting, and you will have your customers in better relation with you. Give them more for their money and get them into a position where they will have a better appreciation of your service. It is well worth all the money you can spend to get that kind of business. In the meantime, while you are pushing these smaller things you can gain knowledge of what the cooking process is. We know it is a good thing, but we do not believe you will do well with the electric-cooking proposition until you know more about it. Reading is simple, but until people have been taught the alphabet in the good old-fashioned way they don't make much progress in reading.

THE PRESIDENT: The next paper is that on *Line Construction for Overhead Light and Power Service,* by Mr. Paul Spencer. Unfortunately for us, but fortunately for Mr. Spencer, he is now somewhere between here and Europe. However, Mr. W. D. Partridge, who assisted Mr. Spencer in the preparation of the paper, is here, and I will ask him to present it.

Mr. Partridge presented the following paper:

LINE CONSTRUCTION FOR OVERHEAD LIGHT AND POWER SERVICE

An electric light and power system can broadly be divided into three parts: the generation, the distribution and the utilization of the current. The progress made in two of these departments, namely, the generating and the utilization of the current, has been constant and rapid. The greatest possible care and thought have been given to designing and building the power station and to its equipment with machinery that will insure uninterrupted service. The improvement in the reliability of arc and incandescent lamps, of motors, and of all other appliances for transforming the current into useful work, has also been a matter for careful engineering study. But the central link in the chain, the distribution of the current from the power station to the consumer, has received much less attention.

Granted conditions where underground construction is economically feasible, the distribution problem stands a chance of intelligent consideration and of being satisfactorily solved along engineering lines, with proper consideration given to reliability of service, freedom from accidents, safety to the public and employees and the future growth and development of the situation. But the possibility of underground distribution is limited to more or less thickly settled territories. Considering electric light companies as a whole, the largest extent of the territory covered must be reached by overhead lines. And when it comes to overhead distribution, the engineer seems to have thought the matter too trifling for his efforts, and to have left the problem to solve itself or to be worked out by the rule-of-thumb methods of the line gang.

The result is shown in the generally poor construction of overhead lines throughout the country and by the general belief that overhead service is much more unreliable than underground service, and is responsible in a great measure for the agitation in favor of placing wires underground, even in localities where the cost of the necessary underground construction is out of all proportion to the revenue to be obtained in the territory. I do not

believe that the objections to overhead lines can be altogether eliminated. A pole line can never be said to be, in itself, an artistic creation, a thing of beauty or an ornament to the landscape, but with more care given to the construction such lines can be made safe and reliable and their unsightliness reduced to a minimum, so as to be unobjectionable as compared with the benefits of the electric service, which only their use will permit.

The problem of constructing a satisfactory overhead line is not an easy one. There are many conditions that are not altogether in the control of the line superintendent. Suitable pole locations are frequently difficult to obtain. The highway along which the line must run is generally, to some extent at least, obstructed by trees which can only be trimmed sparingly, and may also be occupied by the lines of other companies, whose construction must be taken into consideration to avoid an unsightly and dangerous tangle of poles and wires. The back alleys of some of the smaller cities, where alley construction is in vogue, illustrate the hopeless mess which results when two or more electric light and telephone companies build their lines without reference to the lines of the other fellow.

To avoid such conditions and to construct well-built lines should be the endeavor of every electric light manager whose service in whole or in large part is supplied by overhead construction.

The points to be considered in line construction in the order of their importance are the following:

First and foremost, to which all others must be entirely secondary—the safety of the public and the company's employees.

Second—The reliability of the company's service.

Third—Sightliness of the construction.

I have omitted altogether the question of cost, as the cost of a well-built line over that of a poorly-built line should be of no moment as compared with the much greater safety and reliability of the former construction.

These first two requirements, safety and reliability, can be considered together, the first embracing the second, for safe construction implies reliability of service.

To meet these requirements we should use, first of all, structurally sound material, of ample strength to withstand, under all conditions of service, the strains to which the line may be subjected.

The poles should not have less than 7-inch tops, should be set not less than 5 feet in the ground and be held firmly, by substantial guying against side or end pulls.

The cross-arms should be of sound, honest wood, and not the sap-wood variety, which are covered with so-called red paint to hide their defects, and which are made up of the leavings of the mills after the good wood has been cut into building timber and flooring. They should be firmly bolted to the pole and should be braced.

The line wires should not be less than No. 6 B. & S. gauge in size, and they should be strung with ample clearance over highways and footways and should be inaccessible to the general public from bridges or buildings.

The guy wires should be of stranded cable and not solid wire. They should be insulated and, so far as possible, installed so they can not be easily reached from the ground.

Ground wires should not be installed unless they can be connected to a permanent and effectual ground. A ground wire connected to a poor ground not only fails when it becomes charged to give the protection for which it is supposed to be installed, but becomes a positive source of danger to the passer-by.

For the safety of employees, pole wiring should be carried out in a systematic manner, so as to leave space on the pole for climbing and working thereon.

To protect the trimmer, series arc lamps should have absolute cut-outs.

Due consideration should be given to the wires of other companies in the territory. We must remember that the telephone and fire-alarm wires have much less mechanical strength than the line wires used by electric light companies, and that in case of sleet-storms they are the ones that are likely to break and come down, making possible contact with the electric light wires. Personally, I do not believe in installing guard wires as a protection against such possible crosses with other wires. The stable and proper installation of such guard wires in a general distribution system is impracticable, and as they would generally have to be installed they would increase rather than lessen the chances of trouble. When electric light, fire-alarm and telephone wires must be run in proximity, the best results to all concerned and to the public will be obtained by having the electric

light wires on top and above all other wires, and when they must be run on the same side of a highway, joint occupancy of a single pole line is preferable to separate and conflicting pole lines.

Sightliness of construction will be best obtained by having the work done in a systematic manner and by using poles of a uniform height and size, set and maintained perpendicularly.

The cross-arms should be of uniform length.

Wires should be pulled up with similar sag and should not be left with any greater amount of sag than is necessary to relieve the strain due to contraction at low temperatures. Systematic pole wiring, with taps for transformer connections and for branch circuits led across the pole horizontally and dropped perpendicularly, will do a great deal to help the looks of things. Nothing is more unsightly than a pole with wires crossing it and leaving it in all directions and at all angles.

After the line is completed there remains the necessity of constant inspection and maintenance in order to keep it in good condition.

The above points have been enumerated in order to call attention to some of the most important items that enter into the problem of line construction. The subject is one of endless detail, and it may be of interest to quote at some length from the line specification recently prepared for the electric companies of the United Gas Improvement Company and of the Public Service Corporation of New Jersey. Omitting many paragraphs which deal with minor details, the principal sections are as follows:

POLES

Specification.—All poles used must be purchased under, and conform to the company's standard specification therefor. Round chestnut poles shall be used where possible, but wooden piles other than chestnut may be used in localities where it is difficult to obtain chestnut poles. If municipal regulations require a finished pole, yellow pine poles, in accordance with the company's specification therefor, may be installed.

Chestnut poles shall be of sound, live, straight chestnut, squared at both ends, well proportioned from butt to top, peeled, and with knots trimmed close.

The poles shall be of the following dimensions:

Length of Pole	Circumference 6 Feet from Butt Not Less Than	Circumference at Top Not Less Than
30 feet	37 inches	22 inches
35 "	41 "	22 "
40 "	44 "	22 "
45 "	47 "	22 "
50 "	50 "	22 "
55 "	53 "	22 "
60 "	57 "	22 "
65 "	60 "	22 "
70 "	63 "	22 "
75 "	66 "	22 "
80 "	70 "	22 "

Sawed octagonal poles shall be made of long-leaf yellow pine, sound, straight grain and free from sapwood and unsound or large knots.

The dimensions shall be as follows:

Length	Diameter at Top	Diameter at Butt
25 feet	7 inches	10 inches
30 "	7 "	10½ "
35 "	7 "	11 "
40 "	7 "	12 "
45 "	7 "	14 "

NOTE.—Diameters given are the diameters of the inscribed circle.

Poles shall be finished smooth. Butts shall be sawed square and the tops pointed at an angle of 60 degrees. The cross-section of the finished poles, at any point, shall be a true octagon.

Poles shall be shipped unpainted but shall be given one coat of boiled linseed oil before shipment.

Poles will be inspected at point of delivery, and all poles not in accordance with these specifications will be rejected.

Height.—Unless taller poles are required by municipal ordinance, or by exceptional conditions, the standard height in cities or thickly settled localities shall be 35 feet for poles to carry either one or two cross-arms; 40 feet for poles to carry three or four cross-arms, and 45 feet for poles to carry over four cross-arms. For lines in suburban districts 30-foot poles may be used to advantage, and their use is recommended. In general, stability of construction is sacrificed by using poles higher than necessary. The height of a pole is always considered as the total length over all.

Trimming.—Before being set, poles shall be well trimmed and shaved, every effort being made to have their appearance

when set as unobjectionable as possible. The top of each pole shall be roofed at an angle of 45 degrees, as shown in plate No. 1.

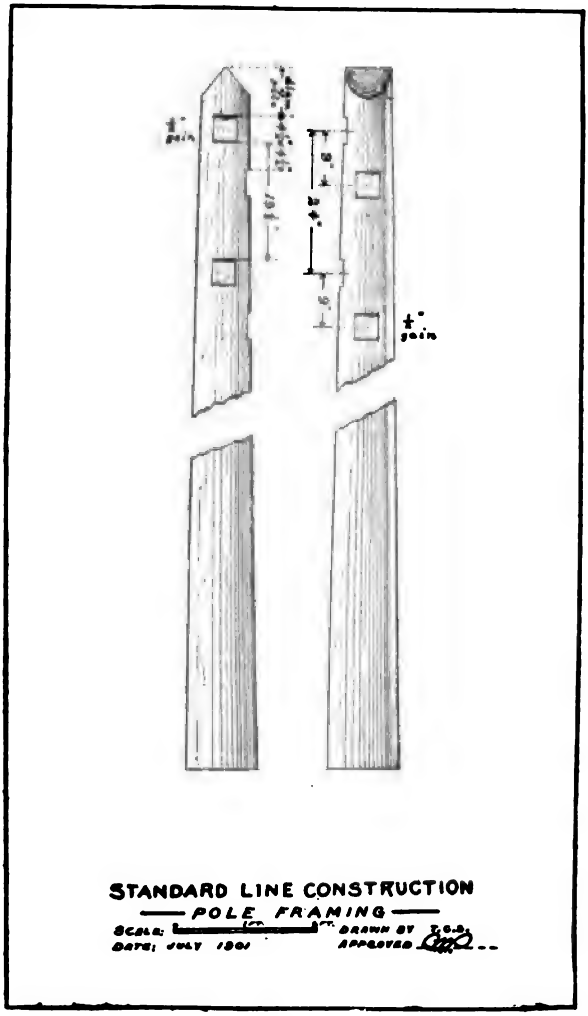


PLATE NO. 1

Cross-Arm Gains.—Gains for the cross-arms up to the expected carrying capacity of the line shall be cut in a pole before the same is set. Gains shall be cut square with axis of pole, and

with all other gains: they shall be four and one-half inches wide to securely fit the cross-arms, and shall be one-half inch deep and spaced 24 inches apart on centres, as shown in plate No. 1. The gains for ten pin cross-arms are 5 inches wide. The distance from the peak of the pole to the top of the upper gain shall be 9 inches.

Painting.—Poles that are to be painted shall be given a priming coat of standard green pole paint before being taken from the yard, special attention being taken to paint thoroughly the roof, gains and parts of the pole to be set in the ground. After the pole is set, and construction line work thereon has been completed, the pole shall be given a second or finishing coat of standard green pole paint. Cross-arm braces, pins, switch-boxes, wooden pole steps and other pole fixtures, shall be painted at the same time.

Pole Numbering.—In order that complete records of the locations and number of poles in use may be kept, it is necessary that every pole belonging to the company, and every pole that is the joint property of the company and of some foreign company, shall be numbered and the initial letters of the company marked thereon.

Spacing.—For heavy trunk lines to carry three or more cross-arms, the spans shall not exceed 110 feet. For main lines to carry two cross-arms, the spans shall not exceed 125 feet. For branch lines that will never carry more than one cross-arm, the spans shall not exceed 140 feet.

Street Rights of Way.—Pole lines on streets are preferable to those over private property. Where possible, poles shall be located at the corners of intersecting streets. Lines should be laid out to follow one side of the street, so that the number of street crossings shall be a minimum. In laying out a new line, care should be taken to obtain an unobstructed right of way. Select the side of the street most free from trees and avoid erecting pole lines that will conflict with existing pole lines of other companies. Objection should always be made to the erection by other companies of pole lines paralleling and on the same side of the street as existing pole lines of this company.

Line Level.—The lengths of poles shall be so proportioned to the contour of the country, or to adjacent poles of exceptional height set to clear obstacles, that abrupt changes in the level of the wires will not occur.

Pole Setting.—Poles shall be set in the ground to depths specified in the table on plate No. 2. At line terminals, corners, curves and other points of excessive strain, poles shall be set in the ground an additional 6 inches. They shall be set to stand perpendicularly when the line is completed. Exception can be taken to this rule in that a very slight lean against the strain can be given to poles at line terminals, corners, curves and other points of excessive strain.

POLE DIMENSIONS AND SETTINGS

Length Over All in Feet	Minimum Cir.		Depth in Ground	
	6 Ft. from Butt	Top	Straight Lines	Curves, Corners and Points of Extra Strain
30	37"	22"	5.'	6.'
35	41"	22"	5.5'	6.'
40	44"	22"	6.'	6.5'
45	47"	22"	6.5'	7.'
50	50"	22"	6.5'	7.'
55	53"	22"	7.'	7.5'
60	57"	22"	7.'	7.5'
65	60"	22"	7.5'	8.'
70	63"	22"	7.5'	8.'
75	66"	22"	8.'	8.5'
80	70"	22"	8.'	8.5'

STANDARD LINE CONSTRUCTION

PLATE NO. 2

Crib-Bracing.—Poles which can not be strongly guyed and which must be set in soft ground, may be given additional stability by crib-bracing, as shown in plate No. 3. This consists in placing at the points of maximum strain, two logs, about 5

feet long and not less than 8 inches in diameter. These furnish considerable extra bearing surface tending to hold the pole in

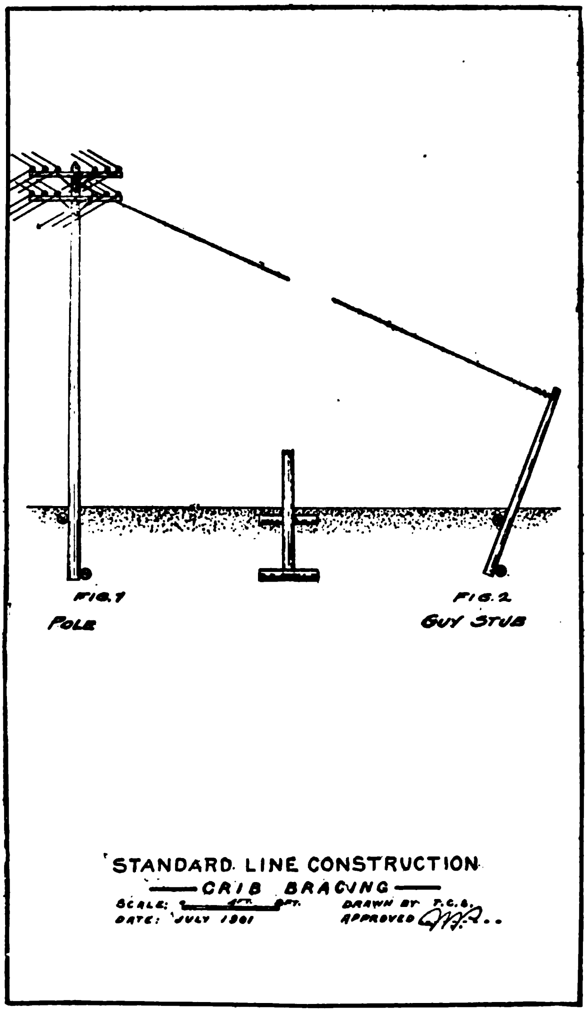
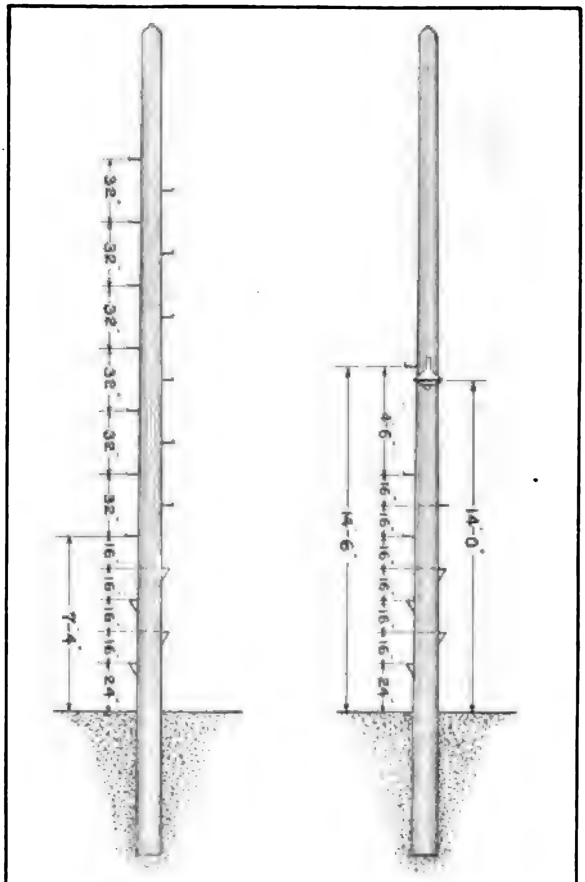


PLATE No. 3

position. The top brace alone, or both braces, can be used according to the amount of additional stability required.

Poles to Be Stepped.—All poles carrying branch cut-outs, incandescent lamps or other attachments that may require fre-

quent attention, as also all testing poles, shall be stepped to facilitate climbing the same. For the same reason, it will be found convenient to step poles carrying transformers. The loca-



STANDARD LINE CONSTRUCTION

——*LOCATION OF POLE STEPS*——

Date May 1st 1904.

PLATE No. 4

tion of steps on a pole is shown in plate No. 4. They should always be placed on a line with the street on which the pole is located.

POLE GUYING

When to Use Guys.—Guys should be used whenever they can be located so as to counteract the strain of the wires attached to a pole, and so prevent the same from being pull'ed from its

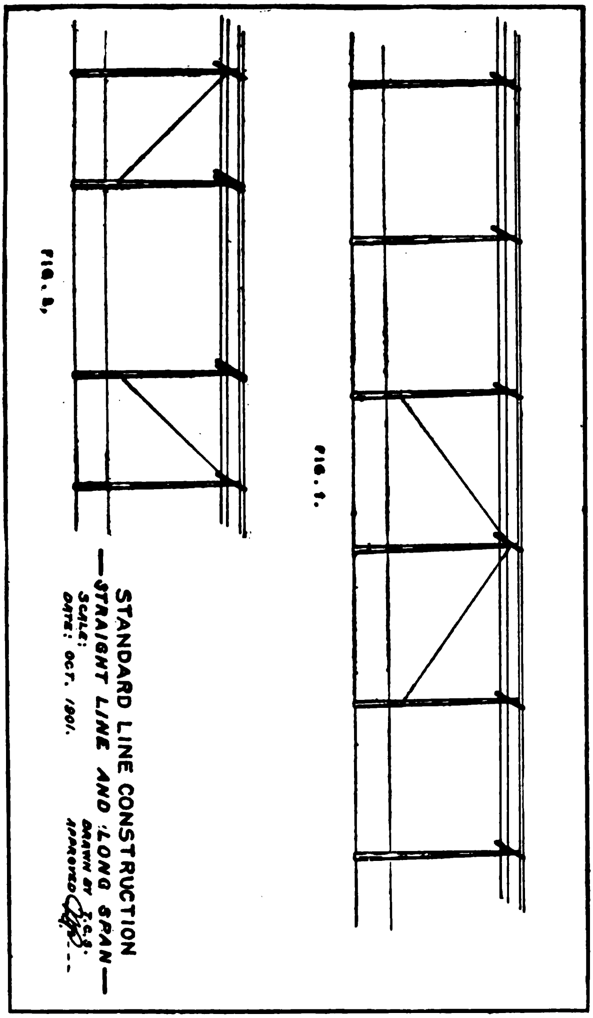


PLATE No. 5

proper position in a line. The following general instructions cover some of the special cases where guying may be required. On

straight lines carrying more than one cross-arm, poles should be head-guyed at convenient intervals, *i. e.,* guys should extend from the top of a pole to the butts of the adjacent poles

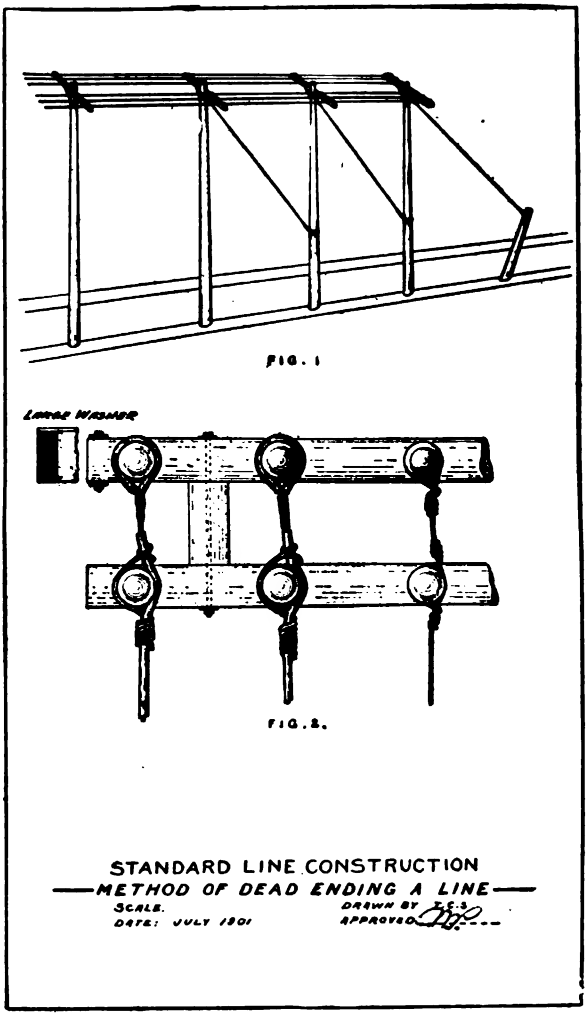


PLATE No. 6

in the line on either side, and if possible this same pole should be side-guyed, *i. e.,* guys should extend from the top of the pole on either side at right angles to the line to guy stubs or other

supports. On street lines, side-guying can be employed only in comparatively few instances. Straight line guying is for the purpose of giving additional stability to a line in case of severe

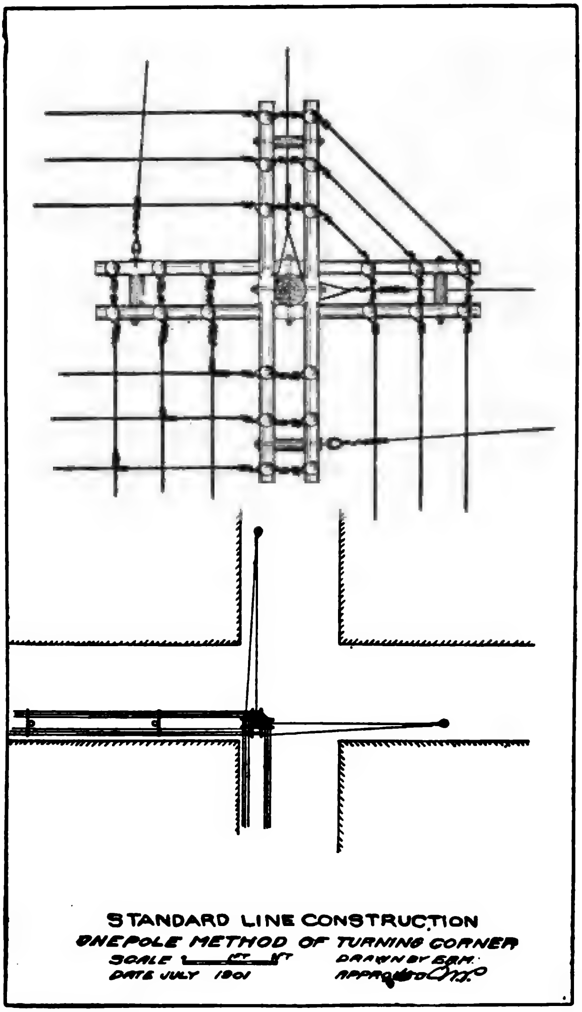


PLATE No. 7

storms, and is illustrated in plate No. 5, figure No. 1. Line terminal poles shall be head-guyed, and on heavy lines the two poles next to

the terminal pole shall be head-guyed to assist the latter in taking the terminal strain, as in plate No. 6. Poles at the terminals of long spans shall be guyed to counteract the extra strain on the

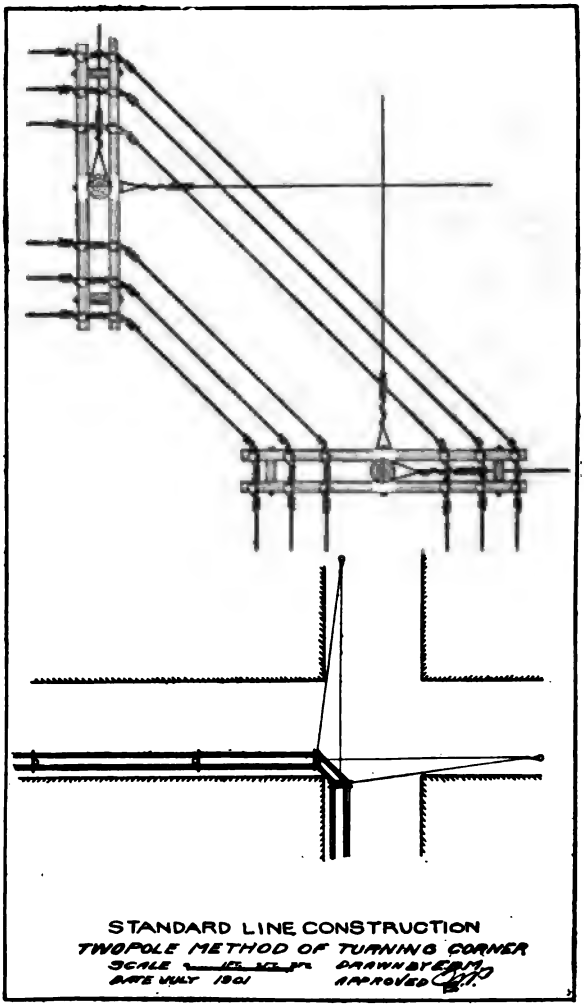


PLATE No. 8

pole due to the long span, as shown in plate No. 5, figure No. 2. In turning a corner with one pole, guys shall preferably be placed as shown in plate No. 7. In turning a corner with two poles, guys shall preferably be located as shown in plate No. 8.

On curved lines carrying not more than one cross-arm, locate guys in a line with the radius of the curve on every pole with an offset of more than 10 feet. On lines carrying more than one cross-arm, locate a guy on every pole having an offset of more than 5 feet. Poles on steep hills should be head-guyed.

Guy Wire.—The material used for guying shall be stranded cable composed of galvanized iron or steel wire. The standard guy cable consists of seven strands of No. 12 B. W. G. galvanized iron wire. A smaller cable may be used for guying cross-arms and light poles, but no cable of less diameter than one-quarter inch shall be used, nor shall solid iron wire be used for guying poles or cross-arms. In connection with the stranded cable, galvanized iron guy clamps and thimbles shall be used. Wrapped joints should not be made in guy wire when clamps can be employed.

Guy Attachment.—All guy wires shall preferably be attached to poles, guy stubs, trees or other ungrounded supports, and when so attached shall not reach within 8 feet of the ground. Unless such attachment be absolutely unavoidable, guy wires shall not be attached to rocks, stone foundations, iron structures or other grounded supports, and such attachments to structures shall be made only with the consent of the owner of the same, and in such a manner that there shall be no danger of any damage to, or interference with the free use of the structure. On poles carrying extra high potential wires, guys shall not be attached to the cross-arms carrying these wires, nor to the pole at or above these cross-arms. When two or more guy wires run to a pole, guy stub or other support in close proximity to each other, the attachment of one guy shall never overlap that of another, but shall be entirely independent thereof. In new construction work, and in rebuilding old lines, guy wires shall be placed and pulled to the required tension before the lines are strung.

Stub-Guying.—When a line can not be properly guyed by means of other poles in the vicinity, guy stubs shall be set, as shown in plate No. 3. Guy stubs shall be of sound chestnut, at least 8 inches in diameter, and of sufficient length to raise the attached guys to the proper height from the ground or from obstacles as herein specified; they shall be set in the ground to a depth of at least 6 feet; shall lean away from the pole to be guyed, and shall be set in the ground according to specifications

applying to poles. Special stability of guy stub setting may be obtained by the use of crib-bracing, as indicated in plate No. 3; or by concrete setting.

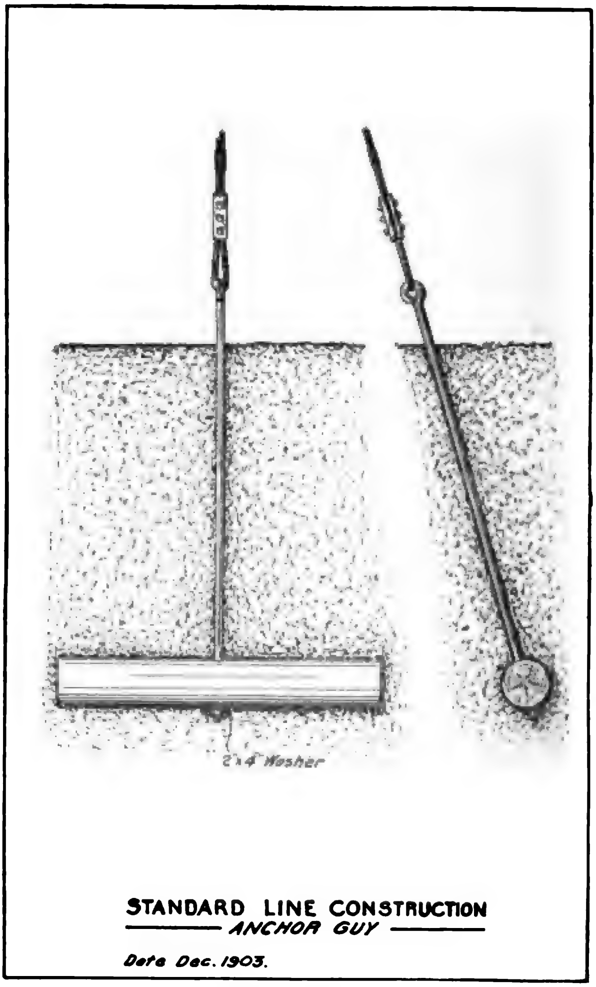


PLATE No. 9

Anchor Guys.—An anchor guy may be employed to guy poles, but must not be installed when the same might interfere with surface traffic. It shall be constructed as shown in plate No. 9. A three-quarter inch iron eye-bolt about 7 feet long shall be

attached at the centre of, and at right angles to, a wooden anchor consisting of a cross-log of sound chestnut, not less than 8 inches in diameter, and about 5 feet long. This anchor shall be set in the ground so that the eye of the guy rod will stand about 1 foot above the ground, the guy rod being in a line with the guy wire attached thereto. The guy rod shall be attached to the anchor by means of a washer and nut.

Tree-Guying.—When neither poles nor guy stubs can be obtained to which to fasten guy wires, conveniently located trees may sometimes be used. Guy wires should not be attached to trees without permission of the owner or other proper authorities. Tree guys shall preferably be attached to tree trunks. When this is impossible, attachment may be made to a live sound limb, close to the tree trunk, provided the limb is not less than 8 inches in diameter. Tree trunks and limbs shall always be protected from injury by the use of tree-blocks between the tree and the wire attached thereto. Tree-blocks should be of chestnut, and shall be placed around a tree trunk or limb sufficiently close together to prevent the wire from touching the same. To avoid injury to the tree, guy wires shall not be wrapped continuously around the same, but shall simply pass around the tree, supported on blocks, as shown in plate No. 10.

Clearance.—Guys shall be attached to poles so as to interfere as little as possible with workmen climbing or working thereon. Every guy which passes either over or under any electric wires other than those attached to the guyed pole shall be so placed and maintained as to provide a clearance of not less than 24 inches between the guy and such electric wires under all conditions of temperature and sag. As changes in temperature will affect the sag of the wires more than that of the guy, the latter being under strain, allowance must be made therefor at the time the guy is installed.

Guy Insulation.—All guy wires attached to poles carrying electric light or power wires shall be insulated by the insertion of at least one strain insulator. In the case of head guys and side guys, the insulator shall be located at the upper end of the guy, and at least 6 feet from the pole, measured horizontally. Where any portion of the guy passes under electric light or power wires, other than those attached to the guyed pole, a second strain insulator shall be used, placed 6 feet from the lower end of

the guy. Guy wires which are attached to a non-insulating support, such as a rock, iron pole, bridge or any other structure, and anchor guys, shall have inserted in them two strain insulators, one being so placed as to protect a man working on the

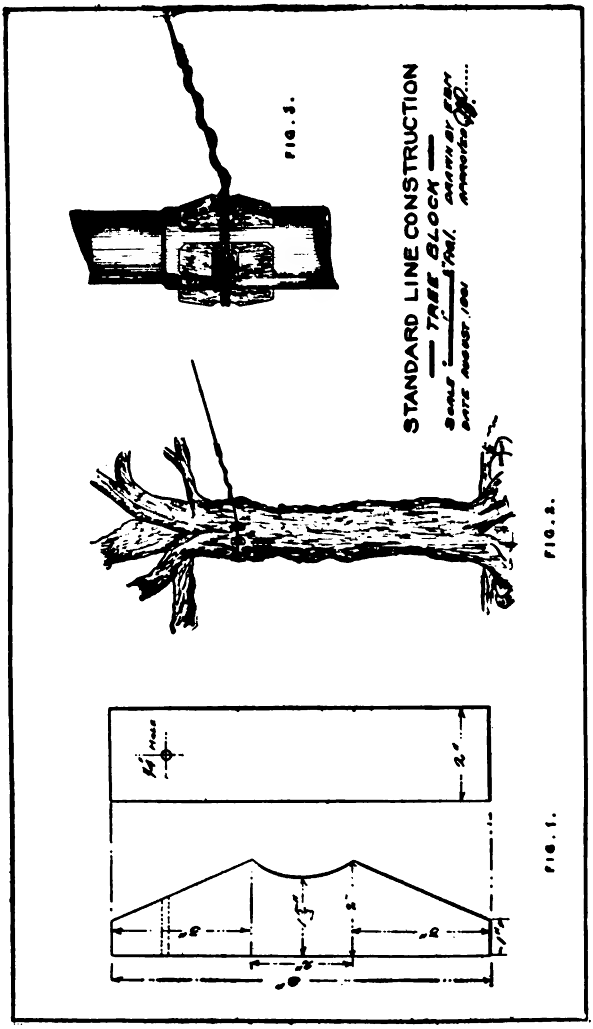


PLATE No. 10

pole from coming in contact with that portion of the guy beyond the insulator, and the other placed so as to be out of reach from the ground or structure.

CROSS-ARMS

Specification.—All cross-arms used must be purchased undcr and conform to the company's standard specifications therefor.

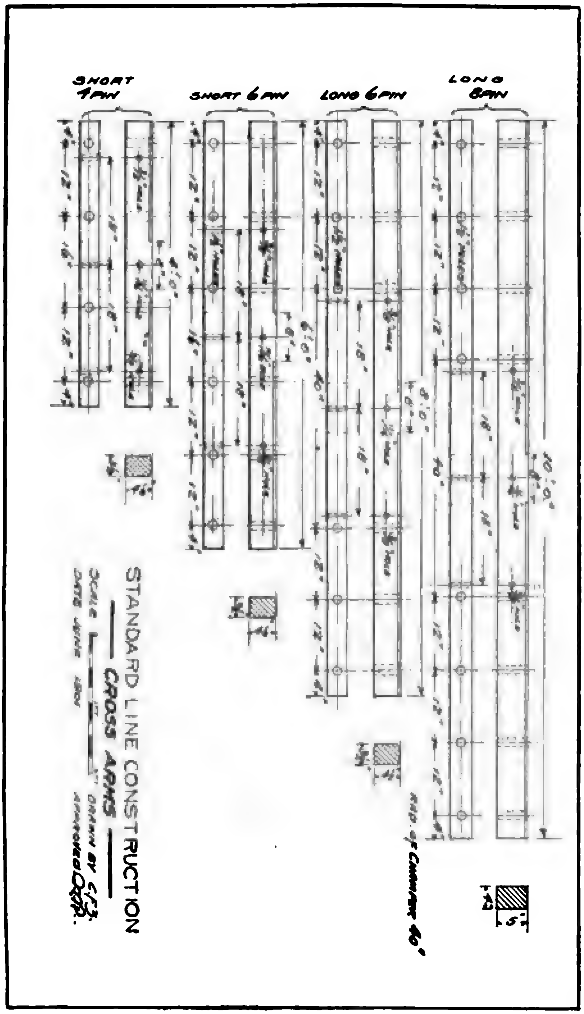


PLATE No. 11

The dimensions adopted by any company will depend somewhat on the character of the service and the surrounding conditions,

and should be uniformly adhered to. The following specification covers the purchase of cross-arms, and the dimensions for two different classes are shown in plates Nos. 11 and 12.

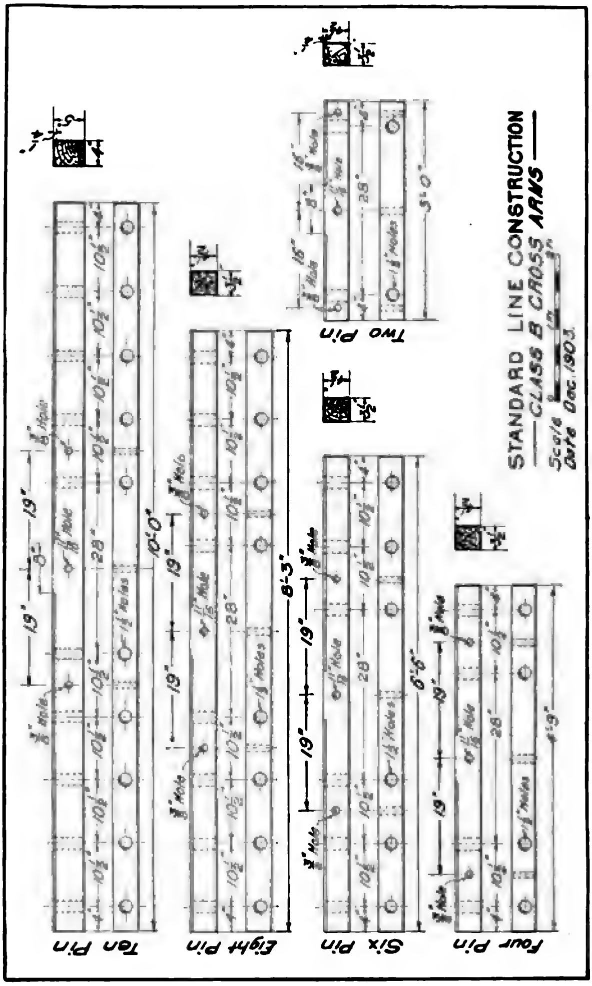


Plate No. 12

Cross-arms shall be made from sound, straight grain, long leaf yellow pine, free from sap wood, shakes and unsound knots.

The dimensions shall be as shown on the attached print, which is included in and forms part of this specification. All cross-arms shall be sawed true and square and the centres of holes shall be on the centre lines of the arm.

Cross-arms shall not be painted, but as soon as cut and finished shall be stored so as to be protected from the weather until shipped. No kiln drying or other artificial methods of seasoning shall be used.

Cross-arms shall be subject to inspection at point of delivery and all arms not conforming to the requirements of this specification shall be rejected.

Painting.—Cross-arms shall be kept under cover until seasoned, and shall then be painted with two coats of standard green white-lead paint before being placed on poles.

Fitting Cross-Arm to Pole.—When possible, cross-arms shall be fastened to a pole before the latter is set. Before being placed on a pole, each cross-arm shall be fitted with two braces. The braces shall be attached to the cross-arm by carriage bolts. When the cross-arm is placed in position, with braces facing away from the pole, an eleven-sixteenths-inch hole shall be bored through the centre of the gain, and a five-eighths-inch cross-arm bolt driven through the cross-arm and pole. This cross-arm bolt shall be of just sufficient length to pass completely through the pole and cross-arm and receive its complement of washers and nuts. One square washer shall be placed under the head and one under the nut at the end of the bolt. Cross-arm bolts of a proper length for the thickness of the pole shall be used. The back of the pole shall never be cut out to allow the use of a shorter bolt, and projecting bolt ends are not to be left on. Cross-arms shall invariably be placed either at right angles or parallel to the line of the street on which pole is set. And they shall always be faced on the opposite side of the pole from that in which the maximum strain comes. On straight lines where the spans between poles are equal, the cross-arms shall be faced alternately on succeeding poles, in first one direction and then the other, as shown in plate No. 5, figure No. 1.

Double Arms.—At line terminals, corners, curves and other places where there is excessive strain on the cross-arms, pins and insulators, the pole shall be double-armed as shown in plates Nos. 6 or 13. Where wires cross from one side of the street to the other, the two crossing poles shall be double-armed, the arms being at right angles to the line of the street. The cross-arms on poles adjacent to crossing poles shall face toward the crossing. At line terminals the last pole shall be double-armed and the cross-arms of the last two poles before the terminal pole faced toward the latter. In turning corners with two poles the

corner pole shall be double-armed, as shown in plate No. 8. In turning corners on one pole double-arming may be used as shown in plate No. 7, if the reverse arms do not cut down the space

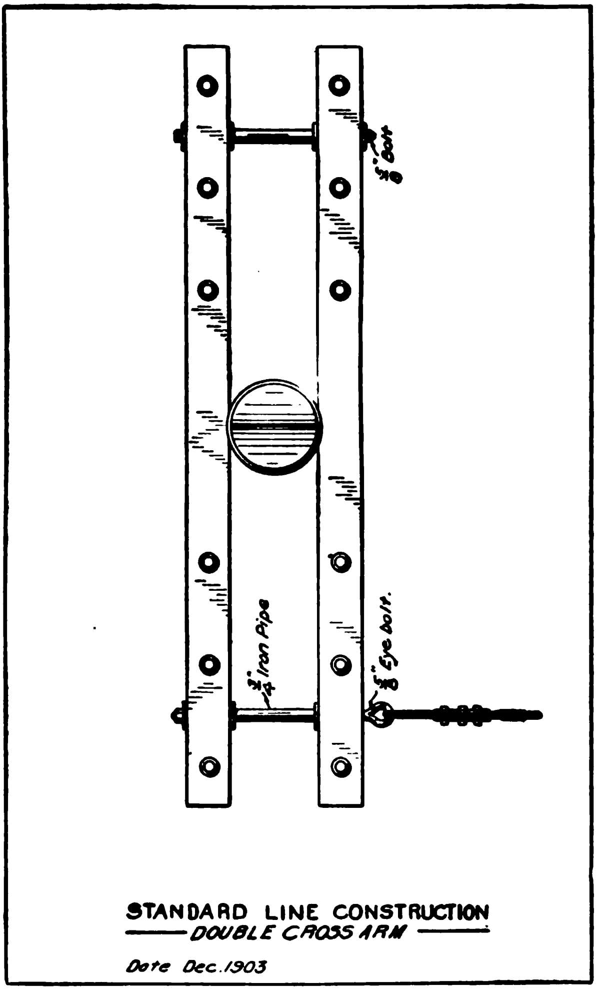


PLATE No. 13

between the nearest wires and the cross-arms so as to make it difficult for the men to climb through. Where on corner poles the use of double arms would reduce the clear space to less than

twenty inches, the double-arming should be omitted and the line held by double-arming on the adjacent poles to the corner pole as in plate No. 14. If the corner can not be securely turned

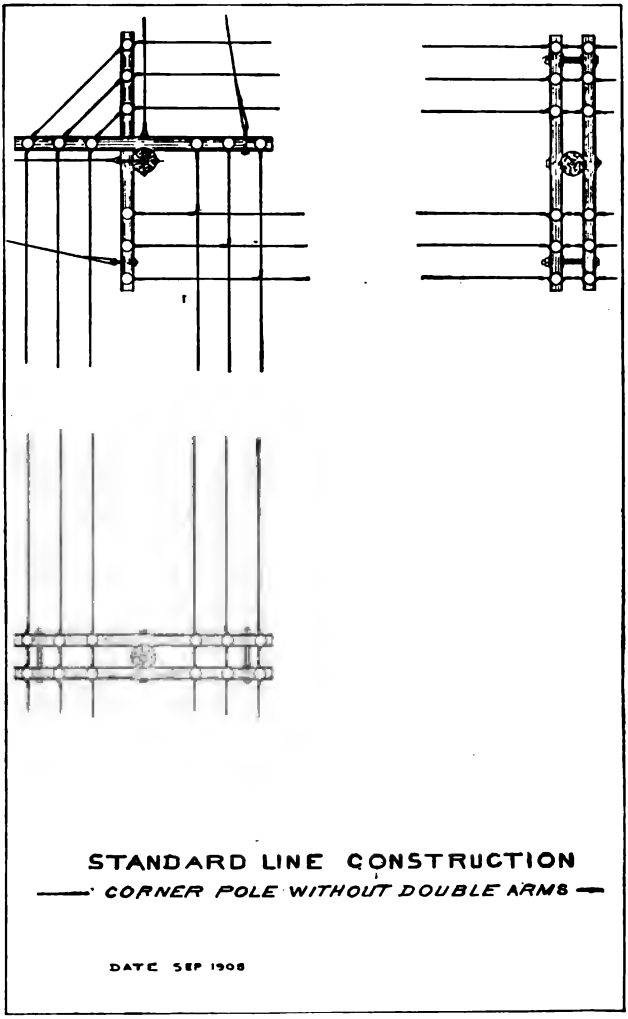


PLATE No. 14

without the use of double arms on the corner pole, longer cross-arms should be used and the wires shifted to provide a clear space of 24 inches between the inside line wires and the nearest face of the pole.

Pins.—Before being taken from the yard, each cross-arm shall be fitted complete with one and one-half-inch standard

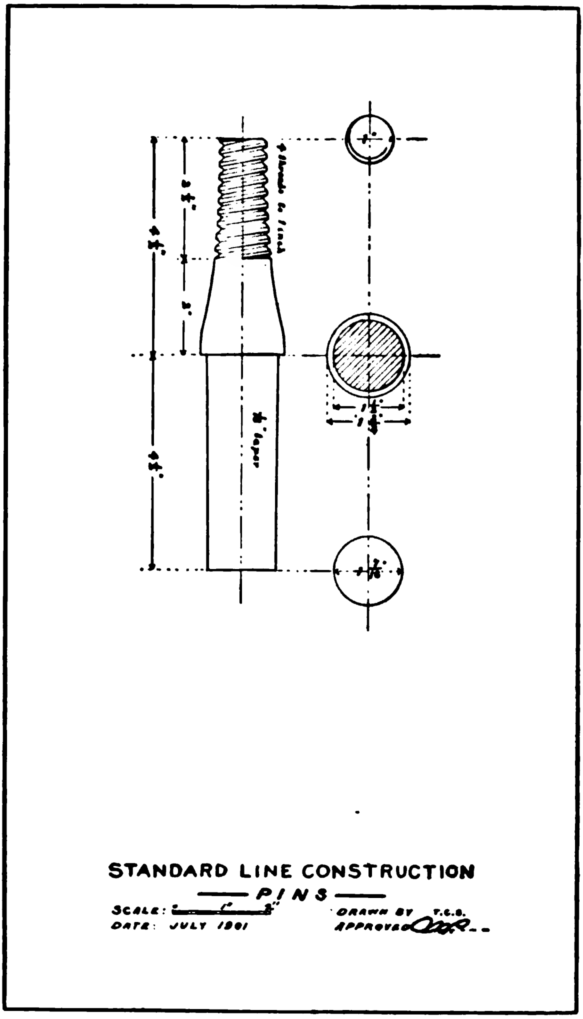


Plate No. 15

pins. A detail drawing of a standard locust pin, giving dimensions, is shown in plate No. 15. Pins shall fit tightly into the holes in a cross-arm, shall stand perpendicularly to cross-arm

when fitted, and shall be nailed thereto with one six-penny nail driven straight from the middle of the side of the cross-arm.

Insulators.—The standard form of insulator for direct-current circuits of all voltages and for alternating-current circuits up to 3500 volts shall be the deep-groove double-petticoat flint-glass insulator. For alternating-current circuits exceeding 3500 volts and not exceeding 5000 volts the triple-petticoat glass insulator shall be the standard. Triple-petticoat glass insulators may also be used for alternating-current circuits under 3500 volts, to reduce noise on telephone wires due to leakage from electric wires on poles jointly used by electric light and telephone wires. For constant potential lines having a voltage exceeding 5000, special insulators of approved pattern shall be used. Insulators should be placed upon the cross-arm pins only when the wire is to be immediately attached thereto, and should be screwed up tightly in every case. If a wire be permanently removed from an insulator, and no other is to take its place, the insulator should also be removed.

WIRE AND WIRE STRINGING

Wire Specification.—Up to and including No. 0 B. & S. gauge, solid wire shall be used for lines. Stranded cable shall be used for all wire larger that No. 0 B. & S. gauge. No wire of smaller size than No. 6 B. & S. gauge shall be used for line wire. For service connections, not more than seventy-five feet in length, and not crossing a street, No. 8 twin or single conductor may be used. The standard insulation for line wires shall be an approved triple-braided weatherproof covering.

Wires Attached to Structures.—High tension lines shall not be supported upon trees, nor should they be attached to buildings. When they must be attached to bridges every effort must be made to so place the wires that they will be entirely inaccessible to the general public. When a high-potential series circuit must be attached to a building in order to supply commercial series arc lighting therein, the wires must be installed in such a way as to be beyond the possibility of accidental contact by people in or about the place, and also so as to avoid possibility of contact with awnings, shutters, signs and similar fixtures on the building. Line wires shall not be attached to wooden bracket-pins.

Clearance.—The clear space between the crown of the road and wires crossing the same shall always conform to municipal ordinances or rules, but in no case shall such clear space be less than 21 feet. Similarly, the clear space between sidewalks and wires crossing them shall never be less than 15 feet. High-tension wires shall clear all roofs in such a manner that they can not be reached from the same. They shall clear other wires, or guy wires above or below, by not less than 24 inches excepting where attached rigidly at poles. They shall be run so that they can not be readily reached from any building or structure.

Tree Trimming.—It is essential for the safe and uninterrupted operation of high-tension lines that they be free from possibility of grounding on trees. It is therefore important that tree branches interfering or likely to interfere with the lines should be cut away. Such trimming must be done with care and judgment and under the immediate supervision of the superintendent, line foreman or other responsible person. Before any trimming is done, the consent of the owner of the trees should be obtained. Opposition to tree trimming may sometimes be overcome by offering to employ a professional gardener for this purpose. If consent to trim trees can not be obtained, tree wire shall be used. Trees can generally be best trimmed in the fall and winter months, when the leaves are off, and the result of the work will be less noticeable. When branches have been cut off they should not be left to litter the streets, nor thrown into the nearest vacant lot, but should be removed in the company's wagons. The stubs of branches should always be painted for their protection and to make them less noticeable.

Running Through Trees.—When lines must be carried through trees that can not be cleared or trimmed so as to give a clear passage for the wires, tree wire of approved insulation shall be used. This insulation consists of a three-thirty-second-inch rubber cover, taped and with two braids over all.

Abrasion Moulding.—Where tree wire is used, if there is danger of limbs or large branches chafing the insulation, it shall be protected by means of wooden abrasion moulding. A satisfactory form of wood moulding is shown in detail on plate No. 16.

Line Sag.—By means of jack-strap, blocks and tackle, or other device, wires shall be pulled up until the sag or dip in the

line between supports shall be as specified in the table, plate No. 17. As will be seen from the table, the dip below horizontal is the same for all sizes of line wire, but varies with the length

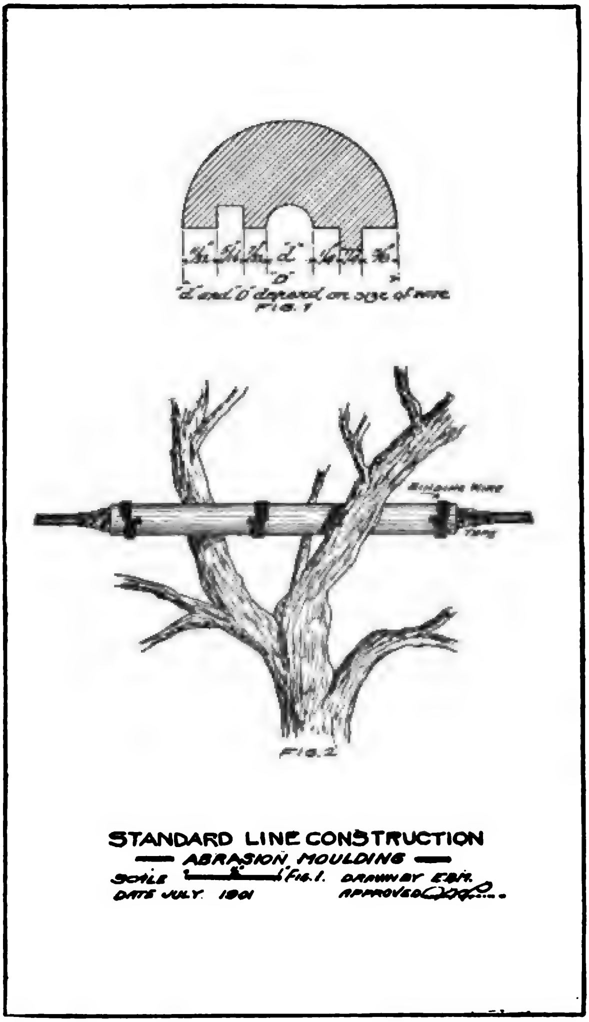


PLATE No. 16

of the span and with the temperature of the air at the time the work is done. Therefore, wires stretched between two poles should all hang parallel to each other.

DIP IN ANNEALED COPPER LINE WIRE.

DEFLECTION IN INCHES.

Span in Feet.	Temperature in Degrees Fahrenheit.						
	30°	40°	50°	60°	70°	80°	90°
50	8	9	9	10	11	11	12
60	10	11	11	12	13	14	14
70	11	12	13	14	15	16	17
80	13	14	15	16	17	18	19
90	14	16	17	18	19	20	21
100	16	17	19	20	21	23	24
110	18	19	21	22	24	25	26
120	19	21	23	24	26	27	28
140	22	24	26	28	30	32	33
160	26	28	30	32	34	36	38
180	29	32	34	36	39	41	43

Soft-drawn copper wire, ultimate tensile strength 34,000 pounds per square inch. Triple braided weather-proof insulation. Factor of safety 4. Minimum temperature—20° F.

STANDARD LINE CONSTRUCTION

PLATE NO. 17

Splicing Wires.—Every joint and tap shall be carefully soldered and taped.

Branch Lines.—When only one or two wires branch from a pole, the tap should be made by the use of spreader brackets,

as shown in plate No. 18. If the branch line carries more than two wires, a reverse-arm should be used. All bends in wires should, if possible, be at right angles. When strung in position,

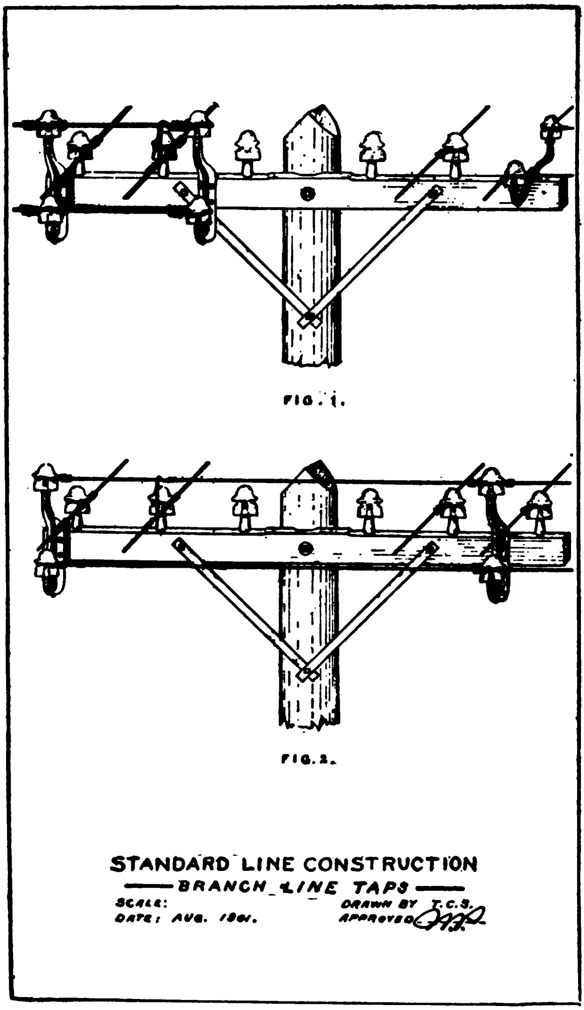


PLATE No. 18

all wires should be entirely free from crooks and kinks, and should not hang loosely between supports. Loosely hung or kinked wires are not only unsightly, but are indicative of poor

line work. Carrying wires across the face of a pole at all angles, and necessarily without proper supports, not only increases the liability of trouble, and makes trouble-hunting and repair work difficult in the confusion of wires, but unnecessarily makes the wires an eye-sore to the public.

Corners.—At right-angle corners in heavy lines, when possible, turn by means of two poles, as shown in plate No. 8. A corner with only one pole may be turned as shown in plate No. 7. The double-arms shall be omitted if necessary to provide space for climbing, and the turn made as shown in plates Nos. 14 and 19. When guys will hold the pole securely, the line wires can be pulled tightly around the corner, but when guys are weak the strain of the wires shall be correspondingly lightened.

Dead Wires.—All wires temporarily out of service shall be left on the poles, but shall be cut dead, as their connection to a circuit-carrying current only needlessly increases the chance of trouble on the lines. Wires permanently out of service shall be at once entirely removed from the poles.

Systems of Distribution.—Commercial circuits must be designed to furnish practically uniform voltage throughout a system of distribution, otherwise satisfactory lighting or power service can not be supplied to consumers. To secure this end, so far as possible, all constant-potential circuits shall be laid out on the feeder and main system, feeders being run from the station or substation to some point of distribution centrally located in the district to be supplied. From this centre of distribution the mains should radiate in such a manner and be of such a size that the drop in potential therein will be as uniform as possible, and as low as is warranted by the costs of construction. The drop of potential in the feeder, between station or substation and the centre of distribution, should not exceed 10 per cent of the delivered voltage. Potential regulators may be used to advantage on feeder circuits, and when the drop therein exceeds 10 per cent they shall be used. In general, consumers shall not be connected to feeders when they can be supplied from distributing mains or branches. Branch lines or mains on the 500-volt-power circuits should be tied together so far as possible, thereby providing an interconnected network of wires throughout a district. Branch lines or mains, however, supplied by separate feeders, shall not be so interconnected.

Temporary Work to be Avoided.—All construction and extension work on circuits shall be of a permanent character, both as to the routes followed and the quality of line work. Rush

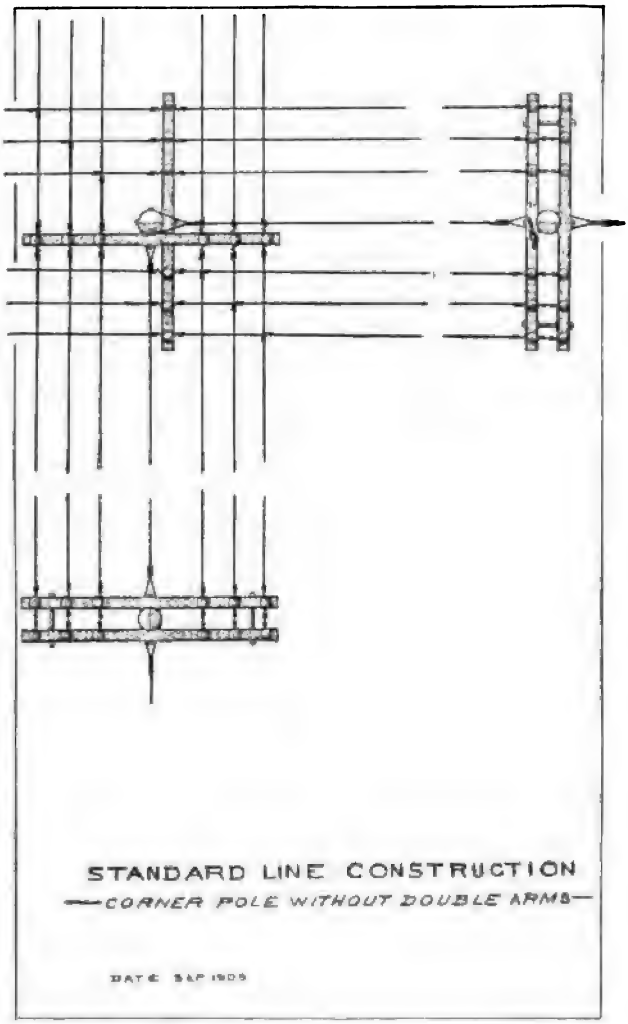


PLATE No. 19

work, short-cuts, skimped materials and other such attempts to hasten the completion or reduce the initial cost of circuit extension, shall be avoided.

LOCATION OF WIRES

Series Circuits.—Series circuits shall start from station, substation or other point of distribution on a given pin and cross-arm, and shall follow this same relative pin and cross-arm throughout its course. Circuits shall not jump from one location on a cross-arm to another location on the same cross-arm, or to a different cross-arm, but shall always be placed on their proper pin. Such a system of confining each circuit to a given pin throughout its course makes trouble-hunting and repair work much simpler than they otherwise would be, and is the only possible way in which circuits can be constructed, maintained, operated and extended in a satisfactorily systematic manner. As series arc and series incandescent circuits are cut dead during the daytime, and will not therefore hamper linemen working on a pole, these circuits can often be run to advantage on the pole pins of a cross-arm. Such an arrangement is also convenient for making lamp loop connections.

Multiple Circuits.—The wires of commercial circuits shall retain the same relative positions on pins and cross-arms throughout their course, and shall not jump from one set of pins to another set on the same cross-arm, or from one cross-arm to another cross-arm. To minimize the induction on alternating-current lines, the two wires of each circuit must positively be run on adjacent pins of a cross-arm. As these circuits are operated continuously day and night, 2200-volt circuits shall preferably be located on the adjacent pins at the ends of a cross-arm. To keep line work as straightforward as possible, and to simplify street lamp, transformer and service connections, all through feeders shall be placed on the upper cross-arms of a trunk line, as far as possible, and all circuits feeding the territory through which the line passes shall be located on the lower cross-arms. Five-hundred-volt wires can often be advantageously located on the pole pins at the centre of a cross-arm.

Secondary Circuits.—Secondary mains shall be run on the lowest or lower cross-arms, and should preferably be run on the end pins of the arm nearest the side of the street on which the consumers are situated. If, however, secondary mains supply both sides of a street about equally, they should be located near the centre of the cross-arm. Secondary mains shall positively be

located on adjacent pins of a cross-arm, and three-wire mains shall be located on adjacent pins and with the neutral wire in the centre.

SECONDARY DISTRIBUTION

Two-Wire Mains.—Where the service connections of two or more consumers are located within a radius of about 500 feet, they may be fed by the two-wire system of distribution from one centrally-located transformer.

Three-Wire Mains.—Where consumers are comparatively numerous in a given block or district, the secondary mains will be practically continuous, and three-wire secondaries should be employed.

Service Wires.—The service is that portion of the overhead system extending from the mains or transformer secondaries on the pole to the consumer's service outlet on the building. Service connections shall not be made with wire smaller than No. 6 B. & S. gauge, except for spans of not more than 75 feet, and not crossing a street, under which circumstances No. 8 B. & S. gauge may be used. In all cases they shall be of such a size that the drop from the transformer to the consumer's outlet, including the drop in secondary mains and service connections, shall not exceed two per cent. Duplex rubber cable may frequently be used to advantage for service connections where the spans are not excessive. The regulation method of supporting wires on buildings shall be by iron brackets, but with wires not larger than No. 6 B. & S. gauge, carrying not over 125 volts and running along straight, smooth walls, or along the fronts of adjacent buildings, and where there will be no strain on the supports other than that caused by the weight of the wire, approved glass knobs, attached to building by screws, may be used. All exposed wires on a building that are within 8 feet of the ground shall be enclosed in conduit.

Location of Transformers.—Transformers must be installed only on poles or in fire-proof vaults. They shall not be attached to walls, roofs or other parts of a building. When on poles, transformers shall be hung on the face, or cross-arm side of the pole. Transformers of 3000 watts' capacity or less may be hung at the most convenient location on the line cross-arm and immediately under the primary wires feeding the same. Transformers

of over 3000 watts and up to 15,000 watts' capacity shall be hung on the line cross-arms, and astride the pole, the hooks of the transformer hangers being attached to that cross-arm which carries the primary circuit feeding the transformer. Transformers of over 15,000 watts' capacity shall be hung astride the pole and on special cross-arms bolted to the pole below the line cross-arms. Transformers larger than 30,000 watts' capacity shall not be hung on regular line poles. Double-arms may be used when they will make it possible to feed primary or secondary wires more directly from insulators to transformers than is possible with the single cross-arm.

Removal of Transformers.—Whenever a consumer discontinues the use of a service for a definite short period his service wires shall be immediately disconnected from the line, and if he be supplied by an individual transformer, this shall also be disconnected by removing the fuse plugs. If the stoppage be permanent, or for a long or indefinite time, the service wires, and the individual transformer, if there be one, shall be entirely removed.

Underground Connections.—When transformers are to be located in basement vaults, the latter shall be built by the owner of the building, in accordance with the requirements of the National Board of Fire Underwriters. The primary wires running down the side of the pole and underground to the vault shall consist of an approved lead-encased twin conductor, which shall be carried through a conduit.

Pole Wiring.—All wiring on the pole and all apparatus thereon should be so located as to leave one side, namely, the back of the pole, free for climbing and working upon. Therefore, all primary and secondary connections of transformers, branch taps carried across the pole on spreader brackets, lightning arrester connections, and all service connections, should be made on the face, or cross-arm side of the pole. Also, twin conductors carried down the pole for arc or incandescent lamps, and cables and conduits for primary and secondary underground service connections, should be located on the face of the pole. If necessary, in order to clear pole steps or cross-arms, that they should be located toward the side, the location selected should be that quarter section of the pole lying between the pole face and the side toward the street curb. All wiring to and from fuse

blocks and the primary line wires, or the transformer primary terminals, shall be done neatly and securely, and with as little slack wire as possible. Wires shall be run horizontally or vertically, and all corners turned with right-angle bends. The use of duplex conductors for pole wiring is recommended as being both more sightly and convenient than single conductors. This is especially so where wires have to be carried down the side of a pole, and should be used in all such cases. Twin conductors, however, shall not be used for primary constant-potential circuit pole wiring unless protected by pole cut-outs.

Fuse Blocks.—To protect both line wire and transformers, there shall be inserted in each leg of a primary circuit, where the same connects to a transformer, a single-pole cut-out of an approved type. Such cut-out blocks shall always be fused, and the fuse wire for same shall be of a size to carry not more than 50 per cent overload on the transformer. Fuse blocks shall be conveniently located on the cross-arm, preferably being placed immediately under the line to which they are tapped. A branch fuse or switch box of approved type should be placed on each leg of a circuit where a set of mains tap to the feeder wires, and also where important branch lines are tapped to the mains. Fuses shall be of ample size to carry the normal maximum load on the branch which they protect, and of a size to open the circuit upon a severe overload or short circuit on that branch, without blowing the fuses on the feeder. The use of branch cut-outs, as described above, is recommended, but not required. Local conditions of operation must be taken into consideration before deciding to locate branch cut-outs, and judgment used in placing them, as the indiscriminate use of such cut-outs might be a source of unnecessary interruptions to the service.

SERIES ARC AND INCANDESCENT LAMPS

Series Arc Lamp Suspension.—No method of suspension for arc lamps can be rigidly specified owing to the various conditions and types of lamps to be covered. Whatever system of suspension is adopted shall be neat, simple and mechanically and electrically secure. Lamps hung from a rigid support will be much less liable to open-circuit troubles than if their method of suspension allows of much swinging, and for this reason the use

of span wires should be avoided. When lamps must be so hung, the span cable shall be a stranded iron or steel cable, and be fitted with a strain insulator at each end. The insulators will be located 6 feet from the supporting poles, as specified for guy insulation. Arc lamps should be suspended so that the bottom of the lamp will be approximately 20 feet above the ground, and when at such a height, the hanger insulator should be drawn close up to the tail pulley but not touching it. When manila rope is employed to lower the lamp, the lamp pulley shall have some catch arrangement that will relieve the rope of strain. Every series arc lamp shall be equipped with an absolute cut-out of approved type, and shall have a double insulation between the lamp and the supporting rope or cable.

Series Arc Lamp Loop.—When the lamp loop runs down the side of the pole, and this method of construction is recommended as being both more sightly and reliable than when the conductors are suspended in the air, duplex conductor shall invariably be used. This conductor shall be No. 8 B. & S. gauge, and for arc lamps shall have a rubber wall of not less than three-sixty-fourths inch and a covering of braid or tape on each conductor, and with a covering of braid over all. The duplex conductor as specified above shall be attached to the pole by means of standard deep groove, double petticoat insulators on iron brackets, or may be run through an approved insulating conduit that is securely attached to the pole by means of metal clamps. If glass knobs or porcelain knobs or cleats be used, each conductor of the duplex cable shall have a rubber wall of not less than three-thirty-seconds inch, and a covering of braid or tape on each conductor, and with a covering of braid over all. A typical method of series arc lamp suspension that is recommended as being both neat, simple and mechanically and electrically secure is shown in plate No. 20.

Series Lamps Attached to Buildings.—The use of series lamps in buildings or attached to buildings should be avoided. Series arc lamps so installed must be located at least 9 feet from the floor, and in every way beyond the possibility of accidental contact by people in or about the place. They should be of a type having a ball-shaped globe enclosing the carbons, holders and the lower frame of the lamp. The lamps, wires and all fixtures for series arc lighting in buildings shall be installed by the com-

pany and in accordance with the Rules and Requirements of the National Board of Fire Underwriters. A switch of approved type that will cut off the current entirely from an installation

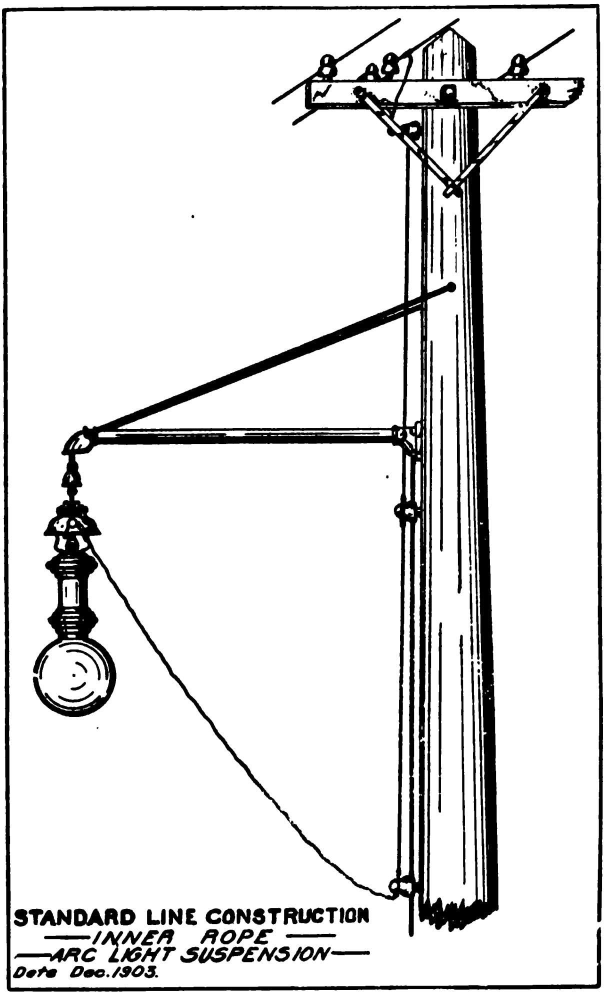


PLATE No. 20

shall be placed at least 10 feet from the floor where the circuit wires are first attached to the building, and at a point at all times accessible from the street.

Series Incandescent Lamps.—Series incandescent lamps will be run on constant-current circuits controlled by some form of regulator, preferably automatic, located at the station or substation. It is recommended that shunt box or similar systems be not used. Each series of lamps should be run from the regulator on a separate circuit, common returns for two or more series being avoided, and the series circuits throughout should be electrically independent of the commercial service. The lamps should be suspended from poles on fixtures of an approved type, having insulated heads, and lamp sockets with approved cut-outs. Fixtures shall be of such length and so attached that the lamp shall be 3 feet 6 inches from the pole and 14 feet above the street, unless otherwise specified by municipal contract. They shall be firmly attached to the pole by means of two 4-inch lag bolts. If the series circuit to which an incandescent lamp is to be connected is on the same side of the pole as the lamp fixture, if there are no intervening cross-arms or line wires between the circuit and the fixture, and if the drop does not exceed 15 feet, the connection to the lamp may be made by dropping the No. 6 B. & S. line wires from the break-arm insulators in the circuit to the line insulators at the lamp end of the fixture as in plate No. 21. If the circuit is on the opposite side of the pole from the fixture, so that the wires installed as above would cross the pole, or if there are intervening arms or line wires, or if the drop would exceed 15 feet, then the connection to the lamp shall be made by means of rubber-covered duplex conductors attached to the pole and installed as in plate No. 22. It is recommended that duplex conductors be used in all cases for series incandescent lamp loops.

GROUND CONNECTIONS

Grounds for Lightning Arresters.—When lightning arresters are to be placed on a pole, special attention shall be given to making a good ground connection. A piece of No. 4 B. & S. gauge insulated copper wire shall extend down the pole from the arrester location to a suitable ground, as hereinafter specified. This ground wire shall be as short, straight and free from coils or turns as possible, and shall run down the side of the pole enclosed in a half-round wooden moulding, which latter shall

extend to a depth of at least 6 inches below the surface of the ground. The part of the ground wire below the surface of the

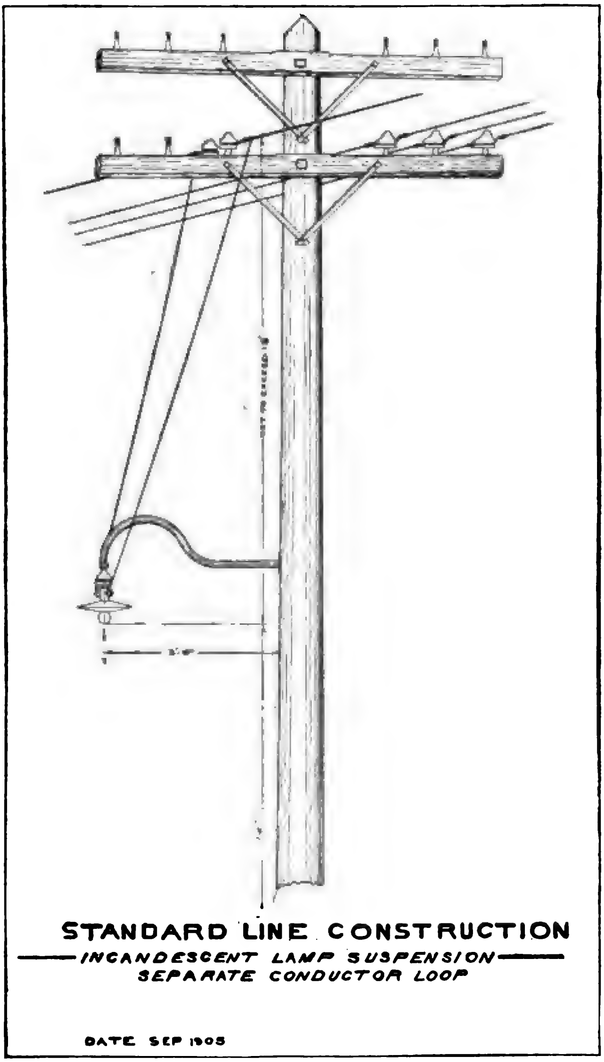


PLATE No. 21

ground shall be cleaned free of insulation. This ground wire shall preferably be carried under the ground in as direct a line

as possible to the nearest service water pipe and connected thereto by being sweated into a lug attached to a clamp, the clamp being

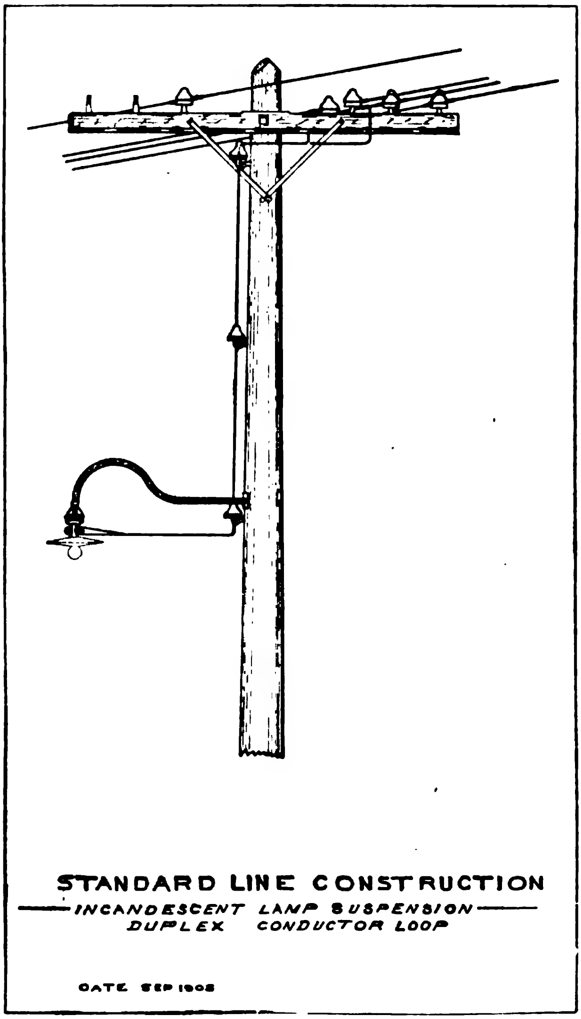


PLATE No. 22

firmly bolted around the pipe. The water pipe should be cleaned bright before the attachment is made, and the clamp and part of the pipe adjacent to it painted with asphaltum paint after the con-

nection has been made. If no water pipe is available for a ground connection, the ground wire should be attached to a plate of No. 16 B. W. G. copper containing not less than four and one-half square feet of surface, and should be riveted and soldered securely to both surfaces thereof. If the soil at the base of the pole is suitable for a good ground, the pole hole shall be dug one foot additional in depth, or if the pole is already set, a hole not less than 6 feet in depth shall be dug beside the pole, and a 6-inch layer of crushed charcoal or coke placed in bottom of same. The copper ground plate shall then be placed thereon and covered by an additional layer of 6 inches of crushed charcoal or coke. If the soil at the butt of the pole is not suitable, the plate shall be placed in a bed of charcoal or coke as specified above, in a hole which will furnish a suitable ground as near the pole as possible; the ground wire being run under the surface of the ground in as straight a line as possible from the foot of the pole to the ground plate.

Grounding of Low-Potential Circuits.—The neutral wire of three-wire direct-current circuits shall be grounded at the central station and shall be grounded every 500 feet in overhead lines. The secondary systems of all distributing transformers shall be grounded. This should preferably be done at each consumer's installation by a ground wire connection from the service outlet to the city water pipe system as called for and described in the paragraphs covering the grounding of secondaries in the company's wiring rules.

FOREIGN LINES

Limiting Attachments.—Extensions to the company's lines should preferably be made by the erection of independent pole lines. Attachments should not be made to poles of foreign companies, even though there be agreements permitting joint use, unless the conditions for any particular extension make such attachments necessary, but joint occupancy is always preferable to parallel or conflicting separate pole lines on the same side of the street.

Independent Cross-Arms.—Foreign attachments shall not be made to cross-arms carrying the company's wires, nor shall wires of the company be attached to foreign cross-arms. The use of wooden bracket pins instead of cross-arms by foreign companies

upon the company's poles shall not be allowed, excepting that one bracket pin may be placed on poles set on private property, when this pin is for the purpose of supplying a telephone service.

Cross-Arms on Poles Carrying Foreign Wires.—On all poles where the company's lines are below those of a foreign company, ample space should be provided between the inside wires.

Location of Wires.—On all poles jointly occupied by the wires of the company and those of another, it is recommended that the company's wires be placed on the top cross-arms, and above all other attachments. A clear space of 4 feet (two gains) should separate the company's wires from foreign wires.

Foreign Cables.—Foreign grounded cables should be so installed that workmen can not make simultaneous contact with high-potential wires and the grounded cables.

Interference from Lines of Other Companies.—In constructing overhead lines careful attention should be given to avoiding any possibility of contact between the company's poles, lines or fixtures and the poles, lines or fixtures of other companies. It is not sufficient for the superintendent or line foreman to see that the construction on the company's poles and on jointly used poles is in good condition. It will also be necessary for him to see that the lines of foreign companies which are attached only to their own poles, but which are near to, or cross the company's lines, are so installed that there is ample clearance between the two lines and so that accidents are not likely to bring them in contact. Guy wires and telephone services should be given particular attention. The superintendent should oppose any construction on the part of other companies that is likely to cause trouble to the company's service. Where there are two or more companies operating overhead lines in the same territory the man in charge of the line construction of each company should recognize the fact that the presence of the other company's lines entails on him the necessity of so constructing the lines of his own company as to avoid possible interference or contact with the lines of the other companies. Line superintendents should take up with the line superintendents of other companies in their territory all matters of construction where the overhead lines are likely to interfere with each other, and come to a mutual understanding as to the essential points necessary to insure non-interference.

INSPECTION OF LINES

Every portion of the outside overhead construction of the company shall be carefully inspected at regular intervals by an inspector detailed for the purpose, and where found to be in a condition, either through accident or decay, or from any other cause, that might make an accident of any kind possible, shall be repaired at once, the repairs being carried out in accordance with these specifications. This inspection must cover all poles, guys, lines and line apparatus belonging to or operated by the company, either on public highways or on private property, and all attachments of the company on foreign poles. It must also cover the attachments of whatever kind, made to the company's poles by foreign companies, and all conditions affecting or likely to affect the safe operation of the company's lines. Any conditions found in the construction of a foreign company that might affect the safe and uninterrupted operation of this company's system shall be immediately reported to the proper officials of such foreign company so that the same can be corrected. The inspectors should be supplied with suitable note books or blank pads on which to note defects in the line construction of the territory covered, which should be turned in daily and immediately attended to by the repair department.

DISCUSSION

THE PRESIDENT: This paper has been prepared with a great deal of care, but it is hardly one we could take up and discuss at the present moment. It is, however, of great value, and I hope every manager and superintendent here will see that his head lineman, at least, has a copy of it placed in his hands, as this, in my mind, will have much to do toward improving the construction throughout the country. Is there any discussion of any portion of the paper?

MR. C. T. MORDOCK (Terre Haute, Ind.): I would ask Mr. Partridge if in making wire joints he has ever used the McIntire sleeve adopted by telephone companies, and, if so, what satisfaction it has given for electric-lighting line construction.

MR. PARTRIDGE: I think all joints on distribution line work are made without the McIntire sleeves, but I am familiar with a transmission line three miles long, carrying 13,000 volts on No. 00

copper wire, that was joined with McIntire sleeves, apparently with satisfaction, having been maintained for approximately two years with no trouble whatever from the joints.

Mr. S. G. Rhodes (New York City): I ask Mr. Partridge if he thinks the best results would be obtained by putting all lines on one pole, rather than putting the electric-light company's lines on its own poles and confining the telephone and fire-alarm systems to their own poles.

Mr. Partridge: If you have a street through which you are going to send three or four kinds of service—as electric light, telephone and telegraph—it is impossible to maintain independent rights of way. It is certainly desirable, from the standpoint of the electric company, to have one company take one side of the street and the other company take the other side, thus keeping electric-light wires entirely separate from telephone wires. From the standpoint of the public, one set of poles is enough, and I think the company ought to meet this proposition partially from the standpoint of the public and attempt to set as few poles as possible on the streets.

Mr. McCabe: I ask Mr. Partridge if he has found a perfectly satisfactory strain insulator for 6600 volts for guy wires on alternating-current circuits. I do not think there has been a satisfactory strain insulator manufactured for high voltage, at all. What does his company do to protect the guy wires from danger?

Mr. Partridge: Personally, I think the best protection for the guy wire is never to bring it within eight or ten feet of the ground, but fasten it to an insulated support, such as a wooden guy stub, entirely out of reach from the ground. There are on the market a number of more or less satisfactory strain insulators, but I do not think that any of them meet all the requirements.

Mr. A. T. Lloyd (Shreveport, La.): I ask the gentleman if in building a junction pole line, as he suggests, he thinks it desirable to install large transformers on the same line.

Mr. Partridge: I should say, if you possibly have room to put them up above the telephone wires, do so.

Mr. Lloyd: I think the best way is to jump out at one side—jump across the street.

Mr. Partridge: I think if the electric-light wires are on

top and a sufficiently large space is left at the centre of the pole for pulling apparatus of this kind up and down, the best place for electric-light transformers is up with the line wires. The fewer cross-arms necessary on a pole, the more simple and straightforward can the wiring be maintained and the appearance of same be kept from being more unsightly than is absolutely necessary.

MR. W. T. MORRISON (New York City): On page 226 it is stated that cross-arms "shall be made from sound, straight-grained, long-leaf yellow pine; free from sap wood, shakes and unsound knots." I have been trying to purchase such cross-arms and find that many of the mills that turn out this class of material have refused to bid on all heart wood. I wish to know if any of the companies have had experience with creosoted cross-arms. I have had some arms inspected that have been on the New Telephone Company's lines some ten years and found them in good condition, and the telephone people feel confident that they will last ten years longer.

MR. MCCABE: I have found that a creosoted arm will go as quickly as one that is not creosoted. I find that white pine lasts equally as long as yellow pine, and in some cases longer.

MR. W. F. WELLS (Brooklyn, N. Y.): On page 209 it is stated that "ground wires should not be installed unless they can be connected to a permanent and effectual ground." I ask Mr. Partridge how he finds a permanent ground where the poles are set in sandy soil? We have tried all sorts of things in Brooklyn, but can not find anything that will do that.

MR. J. T. HUTCHINSON (Rochester, N. Y.): In reference to grounding the neutral wire, we obtain very satisfactory results by using the tracks of the street-railway company as a ground connection, street-car tracks being in all the principal streets of the city. Where we are unable to get a track ground we make a connection to the water pipes.

We have in Rochester, besides the two telephone companies, the city wires, the Western Union and Postal Telegraph companies' wires, the Rochester Railway Company's wires, and those of the Railway and Light Company. In many cases they are all, or nearly all, in the same street. We have found that the only way to obtain satisfactory construction is by the joint

use of poles, erecting the wires in accordance with specifications made by the United Gas Improvement Company. In looking over the ground preparatory to such joint use of poles, we obtained a copy of the specifications drawn up by the United Gas Improvement Company in connection with a telephone company, and a careful analysis of these specifications showed them to be very satisfactory.

MR. MORRISON: I should like to ask the last speaker, if he runs his neutral wires any distance and grounds them at different points on the trolley tracks, how he prevents the trolley current from flowing over the neutral wires and throwing his secondary potential out of balance.

MR. HUTCHINSON: We take care of that by a careful survey of the railway system, and we have no trouble whatever.

THE PRESIDENT: It seems that in the consideration of Mr. Marks' paper this morning sufficient time was not allowed for discussion. The gentlemen who missed the opportunity at the morning session will now be heard.

MR. LOUIS J. AUERBACHER (New York City): Mr. Marks, in his very interesting paper on flaming arcs, discussed same only in connection with street or municipal lighting. According to his figures the flaming arc is apparently at a disadvantage in this capacity, but not to so great an extent as Mr. Marks makes it appear. He also does not take into consideration the very pleasing golden rays and the large amount of illumination per unit, which factors have been so large in making the flaming arc one of the largest features in municipal lighting in Europe. It seems to me that this association is interested in learning the revenue-producing features of this form of illumination, and in the commercial field the flaming arc is sweeping aside all obstacles, helping the central-station man down his antagonist, the gas arc.

The flaming arc will light up the store front more economically and to better advantage than any other form of artificial illumination. The cost of carbons—seven to 10 cents per pair—as well as the cost of trimming, does not enter very largely into the problem, as the customer provides both and in addition buys the current. He receives in return what is to

him a very desirable, economical and attractive form of illumination.

The light distribution, as Mr. Marks pointed out, is the best for store fronts. The distribution is greatest where it is most wanted, namely, at the store front and not 300 feet up the street. The pleasing, penetrating rays can be seen many blocks and make the ordinary arc look like a glowworm.

The latest types of flaming arcs are very simple in construction, even more simple than the enclosed arc.

The great demand for flaming arcs, from every kind of business and amusement places, has produced much revenue for illuminating companies, and if the advantages so evident to the customer may be put before the public, these, as well as the demands of competition, will induce many merchants of every class to install them. In Europe, gas arcs have lost their hold as the cheapest desirable commercial light and the flaming arc has taken their place.

The cost of carbons will be gradually reduced. During my recent trip abroad I visited many of the large carbon factories and found that very rapid headway is being made in this direction. Whereas a few months ago carbons were costing the consumer 15 cents per pair, a carbon burning the same number of hours can now be bought for 10 cents.

Mr. Rhodes: In Mr. Marks' comparison, case No. 1, page 73, of street-lighting systems, the cost of operation for two 500-watt enclosed-arc lamps is given as $8.50 per year, or $4.25 for each lamp. Without at all comparing this figure with that of the flame-arc lamp, I would say that the cost of $4.25 per lamp per year is very much lower than obtains in this vicinity, especially in cities where the demands of service are rigid. Several items have been left out in the cost comparisons, and while they do not in any way affect the comparison, still a total cost is fixed for an existing type of service that is less than its actual cost. The cost of patrolling the circuits, the emergency linemen, and the extra cost to maintain the current supply at night, are not included. The repair cost of 75 cents per lamp per year is a low one, and I can see no other way of arriving at it except to have averaged the costs of the commercial lamps with those of the city circuits. The average cost of 15 cents for an inner globe would allow for the replacement of but two

inner globes per lamp per year, and a life of 2000 hours per globe per lamp is manifestly high. My purpose in calling your attention to these details is not to affect the comparison made between the enclosed and flame lamps, but to have included the entire costs for a city lamp. Being included in the flame-lamp costs, they make the relative advantages of the comparison the same as set forth in Mr. Marks' paper.

(The meeting then adjourned until Wednesday morning.)

ORDER OF BUSINESS

WEDNESDAY, June 6, 1906

MORNING SESSION, 10.15 A. M.

1. Paper—"Business-Getting Methods." By FRANK W. FRUEAUFF
2. Announcements
3. Paper—"How to Make a Small Plant Pay." By D. F. MCGEE
4. Symposium—Methods Used in Securing and Retaining Business. MESSRS. TURNER, WILCOX, TIDD, WALLACE, TRIPP and SCHERCK
5. Report—Free Installation of Electric Signs. JOHN F. GILCHRIST

AFTERNOON SESSION, 3.30 P. M.

1. Paper—"Profitable Co-operation." By J. ROBERT CROUSE
2. Report—Committee to Co-operate with the Manufacturers on Advertising. PAUL SPENCER, Chairman
3. Announcements
4. Report—Committee on Protection from Lightning during 1905. ALEX DOW, Chairman
5. Paper—"Grounding Secondary Alternating-Current Services." By SIDNEY HOSMER
6. Report—Committee on the Fire Hazard of Electricity. H. C. WIRT, Chairman
7. Discussion—"Free Installation of Electric Signs"
8. *Executive Session*

THIRD SESSION

The meeting was called to order by President Blood at a quarter after ten o'clock. Secretary Eglin read a letter from the University of Pennsylvania, inviting the members and guests to visit the university buildings.

The first paper on the morning programme was announced to be *Business-Getting Methods,* by Mr. Frank W. Frueauff, of Denver. Mr. Frueauff not being present, the paper was read by Mr. John Craig Hammond, of New York.

BUSINESS-GETTING METHODS

The most serious problem confronting the central-station manager to-day is the matter of the rates at which electricity for lighting or power purposes shall be sold. With the present tendency toward either municipal ownership or municipal control and regulation of rates, it is more necessary than ever before that the company shall give constant attention to the revenue end of the business.

None of the savings in generation or distribution now known to the fraternity can materially reduce the costs of manufacture nor eliminate the fixed expenses or current losses, but by a constant increase in the volume of desirable business, a company can reduce its average cost of current, due to the fact that the fixed expenses, either for consumption or demand, will not grow at the same rate as the output costs. It is therefore more and more evident that we must hope to follow the plan of the larger mercantile establishments in looking for future growth in large sales at relatively low prices rather than small sales at high prices.

It is to the credit of most central-station managers that they are to-day awake to the possibilities of increased sales of current and that most of them are making an effort to bring their rates to a point that will attract and satisfy the majority of their consumers. In the taking on of new business it is therefore necessary for the company to consider the kind of business to be secured, bending its efforts to attract and cultivate the desirable business and to discourage, as far as possible, the undesirable business.

The writer will make no attempt to go into the matter of rates or costs, but simply calls attention to the fact that in making the rate to the consumer, in order to attract the desirable business, the cost of supplying that service should be borne in mind, and the matter of average costs, which have been so misleading in the past, should, as far as possible, be eliminated.

We can never hope to eliminate all of our unprofitable business, and so long as public service regulations remain as at present it seems impossible for us to be able to put all of this undesirable business where it will at least be self-supporting; but if the

volume of desirable business can be built up so that it constantly bears a larger proportion to the total, the undesirable business can be made a less noticeable burden.

We all realize that a perfect load factor is our ideal, and that the better our load factor can be made, the more closely have we approached success. So far as the lighting end of the business goes, the developments of the last few years have shown that long-hour display or advertising lighting presents the most opportunities for improving the load factor. The tendency toward this class of lighting has spread like an epidemic over the entire country, and it has now come down to simply a question of how to get the business.

The use of electric power, particularly through the daylight hours, is another feature that commends itself to the central station, and is doing much to build up the steam load factor, giving us better station results, particularly in the line of boiler fuel and station labor costs.

How, then, to secure the desirable business is the problem before us. The company realizing the difference between the desirable and undesirable business must necessarily make efforts to secure business along systematic lines, for if this distinction is overlooked we are soon apt to take on, inadvertently, business that requires a larger and larger investment without adequate return.

We have all passed the day when we feel that business will come to the office and we must simply provide means to take care of it. It is now up to us to put ourselves in the position of the merchants with wares to sell in competition with others, and we must go out and find our market and convince the customer that our wares are the ones that will bring him the greatest profits and the greatest convenience.

The writer feels that the best results in getting business are secured through systematic solicitation followed up and interwoven with general and personal advertising. We must see our customers, know their wants and aim to supply them. In many cases we must begin by creating a desire for what has seemed a new article or an expensive luxury. Solicitors or representatives must be thoroughly drilled in their work and should be conversant with the general methods of manufacture, in order to intelligently approach the possible user.

We have found that best results are secured by a constant interchange of ideas among the men engaged in the same line of work, and by a constant and continual drilling and education of the men by some one well posted on the subject. At the outset, it is well for a new man to go about with one who has solicited before, and in that way learn the general line of arguments that are used to induce the consumer to buy; to learn to make a favorable impression upon the prospective consumer, how to adjust complaints, if made, and how finally to close an order. We have found that while many men are thoroughly posted on the advantages of the use of electric light or power, they are not able to hold the interest of the customer, and it is of prime importance that they know how to present the proposition.

Too much attention can not be given by the representative to the complaints, either real or imaginary, which come to his notice. One dissatisfied consumer in a district can undo weeks of work of the most capable representative, and the satisfactory adjustment of a complaint has often resulted in an order, and has made the consumer an active solicitor for the company.

With business men, as well as with the housewife, much of their conversation is taken up with the comparison of their methods. The man with the well-lighted store explains to other merchants his reasons for the lighting and the benefits he has derived, just as the housewife with electric light in her home tells of the advantages it has over oil lamps and the other antiquated methods used by her neighbors.

As the class of business secured by the representative may be good or bad, it is necessary that he should be encouraged in attracting the best business and discouraged in taking on the poor. A contract bringing a revenue of $100.00 a year from one consumer may carry with it a very satisfactory profit to the company, while the same amount of revenue from another party may prove wholly inadequate to pay the costs occasioned, so we have felt it necessary to make our basis of pay to the representatives follow this plan; making the remuneration to the man increase as the value of the business secured increases.

Too much stress can not be laid on the satisfactory results that can be secured by judicious advertising in connection with the visits of the solicitor. It is often impossible for a merchant to give a solicitor any of his time when he happens to drop in to

see him, and by the use of letters asking for an appointment, stating clearly why an interview is sought, time may be saved for the company and for the merchant, for he is waiting to receive you if he has made an appointment.

The sending of attractive advertising, showing forcibly the benefits to be derived by purchasing what we have to sell, will enable the representative to close many orders, and letters then may be sent out after the visit of the representative, bringing out any points that were left open in the interview with the representative, which can be forcibly set out here and may be given more thought by the merchants than if merely a part of the conversation.

The sending of letters to prospective customers unless followed up within a reasonable time by a trained solicitor can not be expected to accomplish results. Many people are in a receptive mood after reading advertising matter, and if we can call and see them soon after, we can get their business, but they will not take the trouble to go down and look for the man who has it to sell. This applies in every line of business, and probably more so in ours than with the so-called retail establishments.

One of the very important features in the getting of new business is in the persistency that is used by the company. We can hardly hope to secure results that would justify any part of the expense of a new business campaign unless it is followed up persistently and systematically.

One visit to all of our consumers or prospective customers will not accomplish much. In many cases the first visit will scarcely give the solicitor an opportunity to meet the consumer, or the entire interview will be taken up with the discussion of the company's policy or in the discussion of some grievance, but it must be borne in mind that these interviews, while not directly productive of good, in the long run are bound to pay handsome dividends.

Our experience, covering a period of several years, shows that the most of our orders are closed after the fourth or fifth visit, and that practically no orders are taken the first time a prospective customer is seen. We have found, too, that where solicitation has been followed up and interwoven with general advertising and with special letter writing, the number of visits has been cut down and the orders secured on an average of about three visits.

The statements just made apply only to the business and commercial districts. In the residence districts we have found it comparatively easy to secure lighting orders on the second visit, but it takes a great many visits to increase their consumption through special uses, such as for long-hour burning of porch lights and the use of special appliances, such as sewing-machine motors, curling-iron heaters, chafing dishes and so forth.

Coming down to a specific branch of business getting, we strongly recommend the use of specialists in particular lines. For example, we have found that a man well versed in the building and designing of electric signs is of material assistance to the representative; that is, while the representative is able to interest the merchant in a proposition for a sign and to convince him of its desirability for his business, if he can then bring to the merchant a man who can give him ideas on how his place may be lighted and advertised to bring out his particular line, it will bring more satisfactory results for the merchant and will usually enable us to secure a larger and more permanent proposition.

We have a man who devotes all of his time to drawing sketches that are submitted by the representative and sign expert. Oftentimes half a dozen sketches are submitted, after the merchant has concluded to put up a sign, before any of them catches his fancy, but it pays well to go to this expense and have him thoroughly satisfied at the outset that he has something particularly adapted to his case.

It is the same with the solicitation of electric power. A special man, who is thoroughly posted on the adaptability of electricity for motive power, can bring the merchant to the closing point much more quickly than if the work is undertaken alone by some man who is fairly well versed in all parts of the business but is not a specialist in this line. We all like to feel when buying that we are doing business with some one who knows thoroughly what he has to sell and how it can be applied. The use of these specialists in connection with the regular representative will tend to impress the prospective customer with the reliability of our proposition.

Another specialist who is of great value to the lighting company is a man to follow up new buildings. He can arrange with the architects when plans are drawn, and advise with the builders as the work progresses, as to how the building shall be wired and the general scheme of illumination.

We have realized the importance of an illuminating engineering education on the part of some of our representatives and at present have a number of them taking a special course with an illuminating engineer of national prominence. We have found their ideas, when presented to the merchants, have been highly appreciated, and we believe that as time goes on there will be a noticeable improvement in our methods and standard of illuminating, due to the fact that they are considering the lighting of the places from a thoroughly professional standpoint and not, as has been our trouble in the past, in trying to see how many globes can be crowded into a given space and enough lights secured, overlooking the thought of its artistic or economic effects.

Careful records should be kept by the representatives of the work they are doing, and records kept in the office of the possibilities outside. Here, again, we find that system plays an important part. With the records kept of the date when the consumer was last visited and the results of the last interview, much time can be saved in going out again and in knowing how to approach him and knowing what his needs are.

One of the most profitable sources of business lies with our present users in increasing their standard of illuminating, and, with business houses, in impressing upon them the possibility for display lighting. This particular part of the business is to be commended. Practically no further investment is needed to secure this business, consequently the profits are very much greater than where new connections have to be made, and once having made a start with the merchant it is easier to get him to use more. With many of our sign, window and outlining consumers we have increased their use of light two or three fold, as the advantages of this class of business have impressed themselves on the merchant's mind.

Another feature we should not overlook in the active solicitation of business is the friendly feeling that will eventually grow up between the consumer and the company. Our greatest handicap to-day is that the officers of a company and the heads of departments can not personally know each one of their consumers; but if we can delegate this work, as is practically done, to the representatives in any given district, the consumer soon comes to feel that he has some one who stands between him and the unknown company who will gladly go to the front

for him and see that his troubles are remedied and that he receives individual treatment, which is so important in these troublesome days.

The force of example is one that commends itself strongly. If the company itself is not a liberal user of its commodity it may create a distrust in the minds of the users, but if the company can make its office or its building a land-mark it has a wholesome effect in convincing the prospects that there is something in display lighting. I believe every company should aim to keep itself in the foreground as the most liberal user of light in its city. It will tend to encourage others to try it; and as the standard of illumination of the company increases so will the standard among the merchants increase. A healthy rivalry of this kind is the best for all concerned. It will build up a feeling in the community that you are enterprising and it will convince the individual that if it is good enough for you it will be good for him.

Summing up the conclusions briefly, I feel that business-getting methods may all be embraced in going after the business systematically, persistently and discreetly, and the more of this that is done the faster the company will grow, the safer its position will become in the community and the greater its earning power for its stockholders.

THE PRESIDENT: This paper and the two following are along similar lines, so we will postpone the discussion until the others have been read.

ANNOUNCEMENTS

THE PRESIDENT: The Co-operative Electrical Development Association, of Cleveland, Ohio, offered $1000 in prizes for the best three papers on *The Organization and Conduct of a New-Business Department Suitable for Central Stations in Cities Under* 50,000 *Population.* The decision as to the winners was to be left to a committee of three central-station managers to be appointed by the president of the National Electric Light Association. In accordance with this I appointed as judges Mr. Douglass Burnett, of Baltimore; Mr. E. H. Mather, of Portland, Me., and Mr. J. E. Montague, of Niagara Falls. The names of the winners in this competition will be announced, and the prizes, in the form of New York drafts for $500, $300 and $200, will be awarded sometime during to-morrow's morning session. It may interest you to know that about twenty papers have been presented, all of them excellent, and the decision of the committee is unanimous. The names of the winners, and the drafts, are in this sealed envelope that I hold in my hand.

I also wish to announce that, in accordance with a vote passed at Denver, there will be immediately following this session (if there is time) an executive session, for the following purpose: "At an executive session to be held on the second day of the annual convention there shall be chosen a nominating committee, to be composed of five accredited representatives from member companies, Class A, in the following manner—" and then it describes the manner, which we will take up at the end of this session, at the executive session.

The next paper on the programme is *How to Make a Small Electric Plant Pay,* by Mr. D. F. McGee, of Red Oak, Iowa.

Mr. McGee presented the paper, as follows:

HOW TO MAKE A SMALL ELECTRIC PLANT PAY

How to make our electrical properties earn a dividend for their stockholders is a subject that is engaging the attention of the brightest minds of the country. The author of this sketch undertakes the task with fear and trembling, but, believing it to be the duty of every central-station manager to contribute his mite toward hastening the solution of this very important problem, he has responded to the request of our president to furnish to this association a paper describing the methods which we adopted to transform into a dividend-earner an electrical property, operating in a town of five thousand population, that had previously been a losing investment. Neither time nor space will permit an elaborate article on this subject, on which volumes are written weekly for our trade papers.

It has been proven that an entirely modern equipment is not essential for the financial success of an electric plant, and a wise manager of a small plant will hesitate before he consigns to the scrap heap equipment that he might, by overhauling and judicious arrangement of same, be able to operate at a net efficiency equal to the most modern equipment, besides saving for his company the amount required for new equipment and increased fixed charges that must necessarily follow such an expenditure. On the other hand, if he finds that his requirements and conditions call for an entirely new installation, he should not hesitate to make it, provided he can get the funds to do so—which is often difficult in a small plant.

The boiler room is usually the most neglected part of a small plant equipment. Uncovered pipes, leaky valves and joints, improper boiler setting, careless firing and injudicious selection of fuel, are a few of the dividend-consuming devices common to small plants. It is well to have as few different sizes of valves, fittings, *et cœtera,* as possible in the piping equipments. By making the nipples and short pieces of pipe of some uniform length, repairs will be simplified and many a shut-down be prevented, and a much smaller stock of fittings will provide for emergencies.

Boilers should be inspected at regular intervals and kept free from scale. Scale in boilers is often the cause of enormous waste of fuel. Every steam plant should have recording thermometers installed in the feed-water lines to boilers. The average engineer in the small plant does not realize the necessity of heating boiler feed water to, at least, 200 degrees.

Many central-station managers would have a rude awakening if they would take the trouble to install recording instruments. Recording voltmeters, as well as thermometers, will provide a healthy incentive for your men to attend to their duties, and will also provide a means by which that mystery of voltage variation, which has given us all so much trouble at various times, may be solved. It is well known that one of the chief difficulties in small plants is to have competent help available when accidents or other trouble occurs, which is generally during the time of the heaviest loads. We have provided for this by dividing the power-house force into three watches, with the understanding that they are to work ten hours per day. This provides double force on duty two hours each day to make all repairs and tide over the peak-load period.

Engines should be indicated regularly, and valves adjusted for the most economical steam consumption. Tests of water and fuel consumption should be made at stated periods. A log book should be kept, showing records of the hourly readings of the various instruments. Daily readings should be made of the switchboard wattmeters. No plant is too small for those instruments. If a plant can not afford load-curve drawing instruments, the engineer or switchboard attendant should plot the daily load from the ammeter readings on sheets similar to chart No. 1. The curve thus drawn will bring before you plainly that hollow place in your load line that must be filled before you can corral that dividend-earning germ which we are all striving to cultivate with more or less success.

The distributing system of a small plant is very often the source of considerable waste. The annual losses from poor line construction, inefficient transformers and badly-designed feeder systems, would go a long way toward paying dividends. The line and transformer losses on above-mentioned plant at present are only 60 per cent of what they were five years ago, when the income was only 25 per cent of the present earnings. We

scrapped thirty transformers and replaced the entire lot with four large ones, using three-wire secondary network with banked transformers to take care of this large increase in business.

The first duty of every manager is to provide for reliable and continuous service. He must furnish "the goods." Excuses won't go with the up-to-date American citizen.

His next duty is to his company. He must see that it receives an equitable return for money invested by it to provide the equipment to supply this service. Before he can do this, he must first know, beyond question, what constitutes the various costs that go to make up the entire operating expenses of the plant. He must be able to make a monthly comparison of his various costs, for it is only by this means that he will be able to keep a check on his operating expenses. By studying carefully all the facts and factors that constitute his costs, the manager will be able to steer clear of the folly of taking on improfitable business.

In plants located in cities with populations of ten thousand and less, the manager must be familiar with every detail of his business. He must be his own solicitor. It has been said that an outside man can interest and get customers that the local manager can not reach. If he can, it is because he is a man better fitted for the business. The manager of a small plant should know ways and means of approaching a prospective customer that a stranger can not know. He should study the ambitions and weaknesses of every prospective customer. Often it is the wife and mother that should be approached, perhaps in an indirect manner. Very often it is the daughters of the house, who aspire to have as many conveniences as their neighbors. A hint from any source should not be neglected. There is always some way to land an interested party. A manager is not worthy of the name if he can not find a way to do this.

Above all, a solicitor must be specific, and must be thoroughly posted regarding cost of installation and cost of operating the article sold; also regarding maintenance of same. He must be able to say, "Buy this; it will cost you so much to install and run, and will give you so much profit." He must be able to meet any argument that may be advanced by his competitors. Above all, he must be truthful. He must not make rash promises. It is well always to allow a factor of safety in this respect. How

gratifying it is to hear from a customer that he is getting better results than you promised him. I can recall one incident that has afforded me considerable pleasure, as well as profit. A German owned a blacksmith shop in our little city. After a lot of hard talking, I got him to install a small motor to operate his tools. Some time after, I called at his shop and enquired how he liked his power. He replied, "One boy put that thing in here, but it would take several good men to get it out again." As he is a very profane man, he used much more forcible language to express himself on this subject. I have used this story many times since, and must say that it has helped to close up the sale of a good many motors.

It is not necessary to be a "hail, fellow, well met." A man does not have to be a "mixer" in the accepted sense to get business. That fallacy has been exploded long ago. A pleasant, cheerful manner, and character to back up his arguments, is his best stock-in-trade.

The manager of a small plant must keep posted regarding the latest and most efficient types of different apparatus, lamps, reflectors, and so forth. He should read all the trade publications; not only the reading matter, but should study the advertisements as well. He will miss a great deal of valuable information if he does not. He will often find the solution in those pages of some difficult problem that has bothered him for months. Many manufacturing concerns gladly furnish binders for their literature. This matter, when properly assorted, represents a mass of valuable information that can be acquired in no other manner, so there is no excuse, save "that tired feeling," for a central-station manager not being up-to-date.

It is somewhat difficult to convince a customer that if his requirements call for a 25-hp motor, he would only have to pay for five to ten horse-power. A very large proportion of the load that can be secured by a small plant is intermittent. The customer averages a payment for only about 25 per cent of his actual installation. By carefully studying the requirements of all prospective customers and familiarizing yourself with their actual costs, you are then in a position to go to any one of those customers with a proposition that will save them money. If you can show the average man that you can cut down his expenses or decrease his manufacturing costs, you will have no difficulty in getting his business.

One of the most desirable classes of customers is the small refrigerating plant; especially when they install brine cold-storage tanks. Arrangements can be made with this class of customers to shut down their motor during peak loads. The cost of this class of power would be only the net additional cost of fuel and proportion of your general expense, as it does not increase the peak load on the station. A careful analysis of costs will work wonders toward helping the manager of our small plants in building up that hollow of low business in daytime.

The manager must be able to plan the most efficient arrangements of machines. In very many cases, such as machine shops, grouping the machines will permit the most efficient operation. In other cases, such as printing plants, individual motor drive is preferable.

It pays to study every installation, giving your prospective customer your very best advice, for there is no advertisement so cheap and good as a satisfied customer. Above all, create confidence, for confidence is the foundation of new business. Pay every attention to the little things. The average user of power knows nothing at all about electricity or mechanics and cares less. What he wants is to see the wheels go round. Have your trouble man call at the various installations at stated intervals, making a report to you of any abuse or misuse of the equipments. The average patron will appreciate this. He can well afford to pay a small sum for this inspection to insure him against a shut-down.

One of the best means to increase your business is to co-operate with architects and builders. The advice of a disinterested party will go a long way with the house owner.

Be prompt in looking after trouble. Let your customers know that their troubles are yours. Make yourself and your service indispensable to them; keep posted in regard to the troubles of users of other sources of power. We have often taken advantage of a breakdown in both steam and gasolene engines to install a motor to help them out of a difficulty, and we have never had occasion to take the motor out afterwards, as the engine would invariably pass to the second-hand man.

With all due respect to advertising, it must not be thought, however, that the getting of new business, in a small city, is dependent on advertising alone. There must be good and reliable

service as a foundation for all this. The service must be continuous and free from interruption. Voltage must be steady. With such good voltage regulators on the market, there is no excuse for poor regulation. Customers' installations must be looked after by the central-station manager to insure their being maintained in good condition. He must watch the little things, keep dim or other inefficient lamps weeded out. At an early date we adopted a liberal policy regarding free lamp renewals.

It is also essential to have a schedule of rates that will attract the long-hour or all-day customers for both light and power.

You must educate the people away from the idea that electric light is for the well-to-do only, for the difference in the yearly cost for redecorating houses where electricity, gas or kerosene is used will often more than pay the entire electric-light bill for the year. Where electric light alone is used, the redecorating cost is about one-half as much as it is where the other illuminants are used.

Regarding advertising in local papers, it is very necessary to retain their good will, and some money can be spent in this manner to advantage.

A short time ago there was an epidemic of burglaries in our city. To one paper we furnished a news item, supposed to be an interview with a reformed burglar, stating that he always gave an electrically-lighted house a wide berth while he was in the business, because he never could tell when a light would be snapped on him from an upper story.

To another paper we furnished a news item, to appear as a statement by a noted detective, advising people to have their houses wired so that the lights in the lower rooms could be switched on from an upper story. We were indebted to an electrical trade paper for this hint. We believe that we received more benefit from this one item in one issue of two newspapers than we should have received from a *bona-fide* advertisement running a year in the same papers. The idea is to take advantage of the psychological moment to instil your proposition into the minds of your prospective customers.

Advertising novelties are of questionable value to small plants. Every manager finds upon his desk every morning a mass of advertising matter, which he immediately consigns to the

waste basket. There may be valuable matter hidden somewhere in this mass. The average manager has too many duties that demand his attention to waste it in wading through so much trash to discover them. Every business man has similar experience. We have found that the better way is to install a number of the articles, the sale of which we desired to push, in a number of carefully-selected places, where they will be seen and talked about; and this, after all, is the only result to be gained by advertising. It is then up to the manager or his solicitor to strike while the iron is hot.

The following charts show the results we obtained by the above methods. In charts Nos. 1, 2 and 3, the curves indicate daily kilowatt output for different periods of past six years. Chart No. 4 represents load factor of plant as described. Chart No. 5 represents the ratio of operating expenses to gross earnings for the past six years.

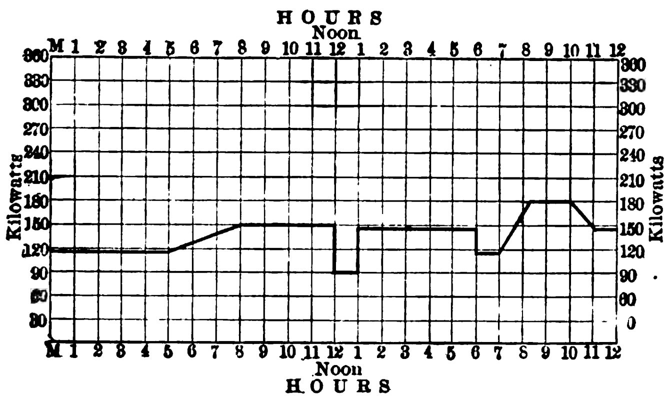


CHART NO. 1—LOAD DIAGRAM JUNE 22, 1905

Horizontal lines show kilowatt-hours Vertical lines represent hours of day, beginning at midnight.

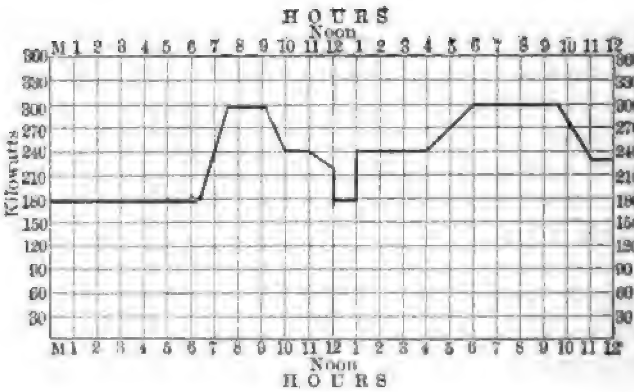


CHART No. 2—LOAD DIAGRAM JANUARY 13, 1906

Horizontal lines show kilowatt output. Vertical lines show hours of day, beginning at midnight.

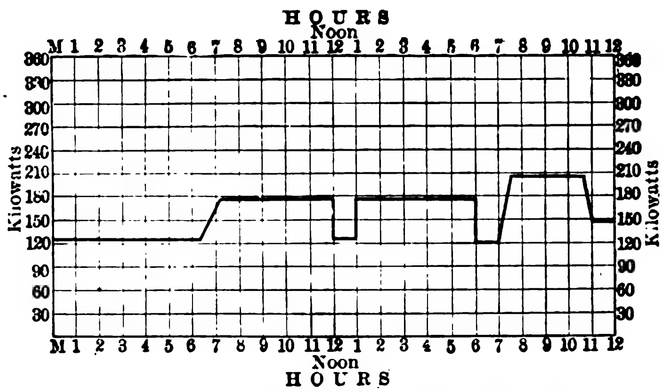


CHART No. 3—LOAD DIAGRAM MARCH 24, 1906

Horizontal lines show kilowatt output. Vertical lines show hours of day, beginning at midnight.

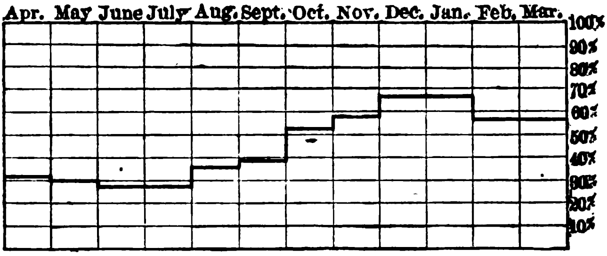


CHART NO. 4—LOAD FACTOR FOR ONE YEAR

In Chart No. 4, 100 per cent represents the total capacity of plant in kilowatt output for year of 365 days, operating 24 hours per day.

The plotted curve represents kilowatt output as registered by switchboard meters during each month of past year. There was no current generated during daylight hours, on Sundays or legal holidays, making a total of 560 hours that plant was shut down during the year, or over six per cent of the entire time.

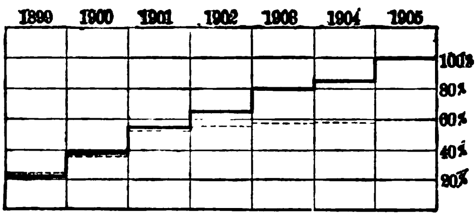


CHART NO. 5—RATIO OF OPERATING EXPENSES TO GROSS EARNINGS

In Chart No. 5, 100 per cent represents gross earnings for one year, 1905. Dotted line represents cost of operating expenses, insurance and taxes for six years.

This plant had been in operation for about ten years previous to 1899. Twenty-four-hour service was started in that year. The writer took charge of the plant in April, 1900.

The above chart shows that it is absolutely necessary to put the plant equipment in the best possible condition before you can hope to keep the operating cost as low as consistent with first-class service.

THE PRESIDENT: We will next have a symposium on *Some Methods Used in Securing and Retaining Business.* This will include contributions from six gentlemen whom I have asked to prepare papers on the subject, and the country will be well represented, as we have papers from Cleveland, Ohio; Lowell, Mass.; Marion, Ind.; Peoria, Ill.; Colorado Springs, Colo., and Birmingham, Ala.

The papers were read by their respective authors, with the exception of Mr. Wilcox's paper, which was read by Mr. F. N. Sanderson, and Mr. Tripp's, which was read by Mr. Wallau. Before reading his contribution, Mr. Scherck made the following remarks:

MR. SCHERCK: When the president of this association asked me to be one of these six Jolly Rogers that have given you their views, he specified that the time limit of five minutes should not be exceeded. I hardly think my paper is within the required time, and I must apologize to the president and to the association for its length. My excuse is that, while I had ample opportunity to write a long paper, I did not have the time to write a short one, and I therefore crave your indulgence.

I think the substance of the whole question could perhaps be given in one minute by referring to the views of the gentleman from Denver when he says: "I feel that business-getting methods may all be embraced in going after the business systematically, persistently and discreetly, and the more of this that is done, the faster the company will grow, the safer its position will become in the community, and the greater the earning power to its stockholders." I believe it all comes down to the question of "eternal vigilance," simply watching your business from every standpoint and all the time. I will endeavor to keep within the time limit by abstracting my paper.

SOME METHODS USED IN SECURING AND RETAINING BUSINESS

MATHIAS E. TURNER

In entering upon this discussion, I will but briefly touch on some of the methods that have been especially successful in obtaining and retaining business in Cleveland.

For the purpose of this discussion, business, as defined by load increase, may be conveniently divided into three classes: (1) that of securing as patrons for the company tenants of newly-erected buildings; (2) that of introducing electricity where other illuminants or modes of power are exclusively used; (3) that of increasing the use of electricity where it and competitive means of light and power are used.

Referring to the first class, early information pertaining to the erection of new buildings is obtained through the various information agencies, Board of Trade bulletins, architects, manufacturers' agents and through reports of the company's line and other inspectors. Solicitors are then set to work. If, however, canvassers are entirely thrown upon their own resources to secure these prospective tenants as customers of the company, they will fail to secure much that should be obtained. The ability of a solicitor to offer to architect, engineer or tenant, the free services of an expert to advise on the most economical and the most modern methods of electrical work, to prepare specifications and estimates of expense for the installation of electrical equipment, and to secure proposals for its execution, many times decides such architect, engineer or tenant of such new buildings to use electricity, and often to use it to the exclusion of any other forms of light or power.

Introducing electricity where other modes of lighting are exclusively used presents a wide field for obtaining new business.

To illustrate: In Cleveland the larger part of the electrical output is used in the main business portion, and in the far outlying districts of the city—that is, that portion of the city which contains the newer buildings. Between these districts, and covered by miles of mains, lie acres of dwellings lighted chiefly

by natural and artificial gas. Recently the Cleveland company introduced and advertised a method for equipping old houses with electric light, payment for such equipment to be made on the installment plan to a wiring contractor. Two canvassers were sent out to solicit business on this basis, and they have continued from the first to write business at a remarkable rate, and at a minimum expense to the company in respect to line investment.

Likewise, a mechanical engineer, through his engineering ability and knowledge of power economies, interests in electric-drive owners of large manufacturing plants who had never given the subject any previous thought. And it is worthy of note that, because proper engineering advice has been given, the successful operation of one large manufacturing plant driven by central-station power establishes a precedent in this respect, and starts inquiries among other manufacturers.

Increasing the use of electricity where it and competitive illuminants are used in stores, is successfully accomplished through the efforts of illuminating engineers working in conjunction with solicitors. For the same expense,' most users of different kinds of light prefer to use electricity exclusively. A lighting expert analyzes the illuminating value of the existing installation, advises the canvasser as to the arrangement and kinds of electric lamps to use to give the most effective light at minimum expense, and estimates the cost of doing the necessary work. The solicitor then has little trouble to induce the proprietor of a store to allow the gas fixtures, for instance, to be taken down and to try the new scheme of lighting. Wherever in Cleveland this has been tried it has met with success, and promises much for the future.

Another method, which is used chiefly among the residences, is suggesting through the medium of a monthly bulletin different conveniences made possible by the fact of electricity being in the premises. And a still more direct method is to send letters and postal cards, apprising consumers of the expected visit of a representative with his samples and catalogues of heating appliances, fans, sewing machine motors, and so forth.

To retain business previously obtained demands careful watch of customers' accounts, to offer them any general reduction in prices that may be offered to prospective customers, and further requires continual investigation of their electrical installa-

tion. It is not always that an electric supply company is forewarned of the intentions of a customer to give up its service for some competing service. And it becomes imperative upon the part of the company to keep its agents circulating among its customers, particularly the stores, suggesting, through its experts, means of adding to the efficiency and attractiveness of the electric light; and all with the view of rendering the best possible service for the least amount of money.

Systematic striving for business probably yields the largest measure of success, and a comprehensive "follow-up" system is important to a sales department. To be complete, it should contain the record of every user and non-user of electricity in the city. Through its medium solicitors' results should be followed. Often one solicitor fails to secure a customer where another solicitor with different personality could succeed; often business is not at once obtainable that will be so in a few months; this and similar knowledge should be in the possession of the sales department in such systematic shape that it will be useful at the proper time. And a sales department should have its efforts complemented by the work of illuminating and mechanical engineers who make a study of illumination and power economies, who keep posted on the newest and best in their line, who are thorough and practical wiremen, and who can estimate closely the cost of work. A department thus equipped assures that electricity will be more greatly advertised through the satisfaction of, and the economy to, the users.

In conclusion, it should be said that, while it may be necessary for a sales department to have a complete "follow-up" system, to publish a monthly bulletin or advertise, to employ expert light, power and heating engineers, it is more essential that all the solicitors should be proficient in these various lines and should be trained to work as a unit and to use the services of experts where expert advice is required. These are some of the principles that stand out prominently as having been particularly successful in their operation in obtaining and retaining business for the Cleveland company.

NORMAN T. WILCOX

At this time, when we are interested in business-getting methods and are spending more or less for printer's ink and

other things, it is well for us to consider the matter from the customer's standpoint, remembering all the time that some form of solicitation is needful if we are to obtain best results.

The fact that so many rate sheets have recently been or are being revised shows that the more progressive plants are realizing the importance of reasonable rates, and that we are being brought to see that at many prevailing rates, the majority of the people served by central-station plants are not able to use as much of our product as they really desire. New and improved lamps and lower-priced and better motors, as well as the development of new and practical devices for other than light and power purposes, are the weapons at hand. Given the devices that we know to be good, we must in some way obtain the *interest* of the prospective customer and create a desire for our product. Often the best way to do this is to make a practical demonstration on the customer's own premises. The fact that we are willing to do this immediately inspires confidence and interest and enables a solicitor of ordinary ability to close business that a more able man would not obtain without such demonstration.

We have recently taken men of good address, who are ambitious and willing, from our operating force, given them a definite district in which to work, equipped them with portable motor cords, high-efficiency or other lamps, and necessary apparatus for making a demonstration on the prospective customer's own premises. If there is no supply wire on the premises, we run a temporary service. With motor customers, we place a motor and run it a few days free of charge, so that that customer can see how much better we can do his work. Realizing that a satisfied customer is a valuable advertisement, the solicitor is encouraged to make occasional calls on all customers in his district to see if the lamps are operating properly and possibly to make suggestions as to better placing of various illuminating and other devices.

These methods are proving most satisfactory and enabling us to get business months and years before we could if we relied on talk alone for an argument.

It costs something to solicit in this manner, as there are cut-ins to be made, transformers and meters to install and some expense for fuel, and so forth. On the other hand, it also costs money for printer's ink, postage, solicitors' time, and discouragement due to slow results and that lack of enthusiasm due to

inability to interest and close business promptly, and it costs even more money to allow our gas friends to hold business that should and could be supplied from our lines.

It is my belief that more money spent for demonstrations, installing proper appliances where they can be used to advantage, will amply justify the expenditure and make central-station managers wonder why so many have forgotten this practical and efficient old-fashioned method of getting business.

GEO. N. TIDD

The increase of sales is of vital importance to the success of the central station. The business can not stand still. It must either grow or diminish; there is no middle road. The most unpromising field can be made productive to an unexpected degree by the simple method of pushing the sale of current by usual commercial methods.

Some of the methods used by the writer which have been productive of results are:

First—Circular Personal Letters

A list of the business houses, factories and residences is made and kept carefully up-to-date. At least once a month a mimeographed personal letter is sent to every name on this list, setting forth one or two advantages of electric current for heating, signs or power, depending upon the character of the business. A number of these letters are prepared in advance, so each name will receive a consecutive line of argument or suggestion. In preparing these letters it will be found a great aid to consult the trade papers appertaining to the various lines of business, to obtain many arguments that will "go home." These letters will usually bring in large numbers of inquiries, which are at once followed up by personal solicitation. When an inquiry is received the battle is then half won.

If the letters after a few months have met with no response they are followed up by a personal call, and the solicitor will find much hard work has been done for him by the advance agent. In many cases these letters accomplish what the solicitor could not do alone. The recipient receives the letter with his mail when his mind is in a receptive mood, and the continual hammering will always bring results.

Second—Newspaper Advertising

A continual round of newspaper advertising is helpful. It is most effective among the merchants who themselves advertise, as they will in most cases scrutinize all advertisements, thus absorbing your arguments, which should be applicable to their business and suggestive of possibilities of increasing and advertising their own business by the use of current.

Third—Display Room

An attractive show window and display room is of great importance. Electric irons, all kinds of heating devices, sewing-machine motors, and, in fact, everything,—are installed upon two or three weeks' free trial. Consumers are urged to try these devices in their homes and rarely do they come back.

Engineering tests are made upon the isolated plant in order to secure its cost of operation and output, and in cases where steam is necessary the plant is temporarily shut down in order to ascertain under actual working conditions the total cost.

In the mill or factory the steam plant is shut down and motors installed throughout upon trial, and the savings, convenience and reliability demonstrated.

Fourth—Schemes of Contract

A large portion of the field from which the new business is recruited is the long-hour business, both light and power. This is the field which the central station should have invaded first if a consideration of the costs were to be properly taken into account, but on account, in the majority of cases, of only one form of contract, usually a quantity rate, a large portion of the long-hour business is not developed. Therefore, I believe it necessary to have a variety of forms of contract which will allow the development of this character of business.

We have, in addition to the ordinary quantity basis, a two-rate contract, planned along the lines of the Wright demand scheme; a flat-rate contract; a flat-rate sign contract; a wholesale quantity basis, based on long-term contract and high guarantee, and a flat-rate power contract, avoiding overlapping peak; all of which are available to any consumer.

Methods of Retaining Business

The retaining of the old business is of even more importance than the securing of new, and no effort should be spared in keeping consumers satisfied.

When complaints come in they are immediately thoroughly investigated, as per form attached, and in many cases a rearrangement of lamps, switches, shades or reflectors, or new lamps, will satisfy and will enable consumer to reduce the current consumption. The alternative contract of higher guarantee and less rate will in most cases solve the difficulty if other means fail.

In the treatment of dissatisfied consumers the utmost tact must be used. Be liberal in dealing with these complaint cases. Your friends do not talk, but your enemies go out of the way to tell their story to the newspapers and your competitors. All of these cases should be carefully handled and no effort should be spared to make the consumer feel that he is justly treated.

One of the points neglected by the average central-station management is the awaiting of complaints. Many of them can be anticipated. Have your solicitors call upon your consumers. Take an interest in their lighting and power, and see that they are securing the best results obtainable before they complain. If this is done, many isolated complaints will fail to materialize and the consumer will feel that you have an interest in his welfare. With the larger consumers, do it yourself, Mr. Manager. Call and see them frequently, and you will find the competitive plant promoter will soon seek greener pastures.

Marion Light & Heating Company

CONSUMER'S COMPLAINT TEST

Date..........................

Name ....

Address ....

Nature of Complaint...

....

....

....

Meter No............................*Make*............................

Capacity........................*Tested by*............................

.............*day of*..........................190...., *shows as follows:*

One-Fourth Load Lamps.............. per cent.

One-Half " Lamps.............. per cent.

Three-Fourths " Lamps.............. per cent.

Full " Lamps.............. per cent.

Total Lamps connected..

Total Arc Lamps...

Heating Devices..

Total Motors in H. P...

Arrangement of Switches: ....

....

....

....

....

....

....

Test of Ground of Wiring:..

....

Test of Wattage Lamps: ....

16 *cp*........................ *make*............................

8 *cp*......................... *make*............................

Arc Lamps.................... *make*............................

Motor No..................... *make*............................

Test running idle..

" " *with Shafting*..

" " *with full Load*...

Running Hours...

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GENERAL CONDITIONS

Note all conditions of operation and advise as to anything which will have bearing on the matter of complaint.

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Signed..

Date................................

R. S. WALLACE

There is a general tendency to believe that others accomplish their work with less effort than ourselves. This tendency, more than any other one thing, is responsible for the lack of a well-organized new-business department in every central station that has been in business long enough to have become well-established.

Central-station operators generally recognize the value of such a department and realize that the ability to sell their service is fully as important as the ability to produce it, but, thinking that special aptness and training are required for the work, they have delayed taking it up until they should have more time to devote to its study.

Assuming that the service it is desired to sell is what it should be, the greatest essential to the conduct of a new-business department is persistence. Make a start, and persistent seeking will develop business in the most unexpected places. If you can't do all you wish, do as much as you can, never forgetting that each prospect closed is so much seed sown in preparation for the later harvest.

Solicitors

Personal solicitation is the most effective means of securing new business.

If your conditions compel you to make a choice of the three principal means of obtaining new business—solicitors, general advertising and direct-by-mail advertising—by all means choose the solicitor, and make strenuous efforts to keep him permanently employed. Make him an old-business retainer as well as a new-business getter.

If yours is a small plant, keep your solicitor in the office during your discount period to handle complaints. The experience will be invaluable to him and the practice will produce a good impression on your customers, since it can not fail to convince them that you are making an earnest effort to assist them in the proper use of your service.

Never lose sight of the fact that a satisfied customer is the best advertisement you can get, and that, as the nature of electric service makes it difficult for the average man to comprehend it

he must be educated up to an appreciation of what is involved in serving his electrical requirements.

It is a mistake to pay solicitors a commission on appliances sold. A flat salary is to be preferred to such an arrangement. A combination of a flat salary and a commission based on actual sales of current, graded in accordance with the investment required to sell this current, and its relation to the peak load, is the ideal method of compensation, but it requires considerable clerical work to handle it. The results secured, however, will justify the expense.

Pick your solicitor with regard, first, to his ability to handle people. A man lacking this quality can't become a salesman. Train your man in your line of work. Have him report to you every day and then discuss with him his orders and his prospects. See that he has access to your trade journals and especially direct his attention to any article that you consider will help him.

Be enthusiastic about the work and your enthusiasm will be communicated to him, sharpening his business-getting abilities, so that he will see prospects for business wherever he goes.

Co-operation with Employees

Do not end your work with training your solicitor. Work up the interest of every man connected with the company. Make them all see the possibilities that can be obtained if every man makes use of the opportunities that come to him every day for boosting the company's business.

Salesroom

Your salesroom is a most important adjunct of your new-business department.

First impressions count for everything with some people and for something with everybody. Your conditions will govern the quantity of apparatus you can display, but even if you show only a flat-iron, you can show it, if you will, so that it will attract interested attention.

Catalogues

Keep carefully filed for reference every catalogue of current-using apparatus you can obtain. Study your catalogues and have your solicitor study them.

Appliance Policy

Make your selling prices for appliances bring you the same rate of profit a dealer would expect, but scrupulously put into advertising or soliciting every cent of such profit. This practice will encourage dealers to handle electrical appliances. Co-operation is what you need, and the more people in your territory who can be induced to push electrical appliances, the better will it be for you.

The practice of selling appliances at cost or less than cost has the further tendency to confirm the popular opinion of the profits from the sale of current. Selling electrical appliances is more a matter of salesmanship than of price.

Convince your customers of the value of your service. Create in them the desire to use it. It can be done by persistent work. Make your terms easy—small payments on long time—and they will buy.

Offer every appliance you handle on trial long enough to thoroughly demonstrate its convenience and utility.

New-Business Index

You need an index of all the buildings in your territory. It should be the map of your new-business department and it should be used like a map. You can make it either a rough sketch or a working drawing, for the direction of your new-business work. The more accurate and comprehensive it is, the more effective can you make your efforts to increase your business. The preparation of such an index is one of the best means of breaking in a solicitor, but in this you must be sure that he appreciates that the work is the means to the end sought, not the end itself. Your work should not end with the preparation of your index. Keep it up-to-date.

Publicity

Make use of every legitimate means of securing desirable publicity for your company. Establish friendly relations with the editors and reporters of your newspapers. In most small towns, news items are not plentiful, and much profitable publicity can be secured through tactfully acquainting your newspaper men with current happenings, such as contracts closed,

contemplated improvements, *et cætera,* or handing them an occasional clipping describing some electrical appliance or some new application of electricity.

Make every piece of company property carry its advertising message.

Cultivating Popularity

Aim to be considered in your community as a public benefactor. Use a portion of your new-business appropriation for purchasing advertising space in programmes for church entertainments and so forth. The space thus purchased has little advertising value, but when the character and energy of the people behind church and charitable organizations is considered, the importance of securing their good will is apparent. Your efforts along this line of work will certainly go far toward establishing your company solidly in the good graces of your customers and possible customers.

Newspaper Advertising

Newspaper advertising, properly used, is an effective new-business builder. If it does nothing else, it will pay its cost in increasing the effectiveness of your solicitors by clothing their work, in the eyes of the people they approach, with a dignity it otherwise would lack.

Newspaper advertising must be general; a selling argument to convince the general reader unconsciously, of the desirability and superiority of electric service.

To be effective, newspaper advertising must be continuous and the copy must be changed daily.

To attract attention, your advertisement must be different from those printed with it. Study every advertisement you see, to find how to make yours different from the general run.

Use in every advertisement the words: "Use Electricity," or their equivalent, and follow this injunction with a reason for using it.

Mail Campaigns

A campaign of direct advertising by mail will still further increase your solicitor's efficiency. Mail will easily reach cus-

tomers who will never see a solicitor, or get to them at times when a solicitor's call would be considered an intrusion and be resented.

Be chary, however, of your use of circular letters and do not place too much faith in the selling power of multi-colored direct-by-mail stuff artistically folded like a table cloth or bed sheet. The chief value of a circular letter is its personal appeal. Therefore is the necessity for its preparation with consummate care, to give it all the effect of a personal appeal to the reader.

Co-operation with Contractors

Keep in touch with your contractors; establish friendly relations with them and consider their criticisms and suggestions. Their co-operation is a valuable means of extending your business and is well worth your strenuous efforts to secure and hold.

Keep informed of the local work your architects have in hand and arrange for regular reports from the building inspector's office.

GEO. B. TRIPP

This subject, to my mind, is one of the most important that a central-station manager has to deal with in bringing about successful results from a financial point of view.

The question of obtaining new and profitable business is the first consideration, but not less in importance is the one that covers the retention of business after it has once been secured.

Therefore, I have subdivided this paper into two distinct classifications, one that of *Getting New Business,* and the other, *How to Retain Profitable Business.*

Each central-station manager must of necessity analyze the conditions which surround his particular plant, and plan for the obtaining of new business, consistent with the earnings of his company. For example, it would not seem to be good policy to go out after new business and wage an expensive compaign, if the kilowatt capacity of the plant were tested to its limit and the company were trying to reduce its floating indebtedness. Assuming, however, that the company has station capacity to spare, and that it is simply a matter of adopting a plan to build up and increase its business along conservative lines, the expenses

of which would be in keeping with its earnings, then I believe a successful campaign could be planned along the following lines:

A business department should first be instituted with a manager in charge. Then the territory of the city should be divided into districts, and a solicitor detailed for each district, so that one man would look after and solicit from consumers in a territory of from six to eight thousand population.

By limiting the territory your solicitors may repeat their calls, and will thus not only succeed in obtaining new business and check up all business which they have previously secured, but may, in addition, keep in touch with the consumers of the company to a degree not possible when your campaign is carried on only in a general way.

The manager of the business department and the heads of the operating departments should meet with the solicitors each morning, and not only should matters pertaining strictly to the business department be discussed, but the solicitors should gradually become acquainted with the main features of the operating departments, so that they can converse intelligently with consumers on questions which may be asked and which may materially affect the policy of the company.

Solicitors should be remunerated on a basis which will hold their interest. Therefore they should be paid either on a commission basis or a small salary plus a commission. To be successful, solicitors must first have a fair knowledge of the devices which they are to sell, of the rates that apply, and, further, they must be in a position to satisfy the consumers of the fairness of the charges which the company makes for its service. The solicitor must at all times use uniform courtesy and patience in his endeavors to obtain business, which factors have a great bearing on the success which the company may enjoy in the community which it serves.

"Follow-up" letters is a method which can be used to great advantage, coupled with the work of good solicitors. I am a great believer in advertising, if used judiciously, but place solicitation first and above all other methods for obtaining new business.

Electric-sign business I think is now conceded to be one of the most profitable classes of business that we can obtain. In

Colorado Springs we have secured contracts for forty electric signs, equaling gross earnings of about $3500. The contract provides that the consumer install the sign at his own expense, and that the company shall charge a flat rate for current consumption and maintenance of lamps on a four-hour basis.

It is true that the electric-sign load crosses the maximum peak of the year, but it is rather unusual for the residential lighting load to cross this peak. The average hours' use of the demand in this latter class of business equals only about one and one-half hours, as compared with a four-hour use in sign lighting.

Before starting on this electric-sign campaign we found it necessary to go before the city council and ask that an ordinance be passed permitting the installation and erection of signs projecting over the sidewalks, provided, however, that these signs were lighted by electricity. The main argument used in securing the passage of this ordinance was that the streets would be more adequately illuminated, that the streets could be policed more easily and at less expense, and, further, that the interests of the business men and taxpayers would be enhanced because of the brilliantly-lighted main thoroughfares.

We also find that there is a considerable field and a growing demand for electric flat-irons, which are sold at cost and which will add, at a conservative estimate, $10 per iron per year to the company's earnings.

The installation of high-efficiency lamps is also a satisfactory method of popularizing the use of electricity, and a company, in my judgment, can not make any mistake by suggesting to the consumer a method of reduction in the cost per unit of light, as it will mean a greater use of the total units in the long run, and therefore an increase in the daily width of the peak and load factor of the station.

The question of how to retain profitable business is also a feature not to be overlooked by any central-station company. The writer is of the opinion:

First—That the rates for service must be as low as possible, commensurate with the costs and securing a fair return on the investment. Charges for both lighting and power service should be based on the hours' use of the service, reductions to follow

the decrease in operating costs. The latter naturally show a material reduction as you increase your sales per kilowatt of station capacity, which result can be brought about by adopting a two-rate system, based either on the connected load or the demand system. It is unnecessary for me to enter into a discussion of the merits of any particular system of charging. A system, however, that tends to induce the consumer, particularly in your commercial district, to use current for lighting or power purposes longer hours each and every day of the year, not only increases your income per thousand dollars' investment, but just as surely increases the security of your holding such a consumer in line and making a "booster" of him for new business in your district.

Second—The service must be maintained at the highest standard, which means that the station regulation must be kept up as efficiently as the best engineering practice will allow, that the various current devices used by the consumer must be inspected by the company's representatives as often as necessary not only to secure a maximum income from the use of same, but, in addition, to see that said devices are operating efficiently.

Further, it is extremely essential that complaints be answered promptly and claims adjusted with a view of not only securing for the company the return justly due, but that, above all other considerations, the claims be settled on a basis entirely satisfactory to the consumers. The best results are attained by adopting a conciliatory rather than an arbitrary policy in your treatment of claims and complaints.

Third—The company should inaugurate in its general policy that each and every consumer should be made to feel that his business is of the preferred class and that the company needs it. In other words, give the consumer the attention that he is accustomed to receive from his mercantile house or the salesman from whom he buys goods, and not assume that he *must* come to you for the commodity that you sell.

Public-service corporations should deal with the general public, and with the municipality that each serves, from the point of view that the electric company has nothing to conceal, and is ready at all times to answer sensible criticisms. Municipal ownership agitation has in the past gained strength because of the

secrecy that has shrouded the reports of operating companies, which has resulted in the general public suspecting that companies were earning enormous dividends.

Let us be fair on this proposition: In the first place, by issuing bonds on the properties in an equitable way; by declaring reasonable dividends on the stock; building up a surplus or sinking fund that is in keeping with the bond issue; and, when earnings exceed the amounts necessary for these charges, then reduce the rates for service rather than increase the dividends. This may sound like an ultra-conservative policy, but such, I believe, is the policy we must enforce in the future to successfully retain the business that we have secured.

LEON H. SCHERCK

David Garrick is said to have remarked that, while he could play tragedy at any time, it required a concentration of all his powers in order to fittingly produce a comedy, and so, while it is a comparatively easy thing to secure new business in the field of electric lighting and power, it is much more difficult to retain it. A former president of this association has said that he would pay a man who could successfully "hold" business twice as much as he would one who could secure it, and our observations in various cities and under varying conditions have taught us the value of his words.

It seems to me that we should strive to secure only such business as we feel reasonably satisfied we can retain, and that after having once secured a customer we should constantly study his needs and at all times endeavor to keep him satisfied. If we do this our "cut-offs" will be comparatively few.

GETTING BUSINESS

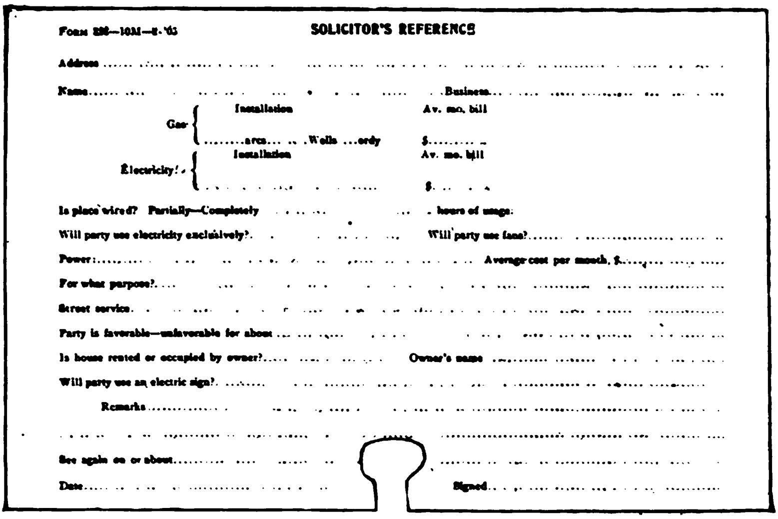
Organization of a Contract Department

In a company starting out to get business the first thing necessary is the organization of a contract department with the proper man at its head. Don't try to get a cheap man—"you can not buy a race horse for a pony price." Select some man with good address, of some experience, polite, tactful, and one who has made a study of human nature—one who can properly meet the president of a bank one minute and an ignorant peanut vender

the next. Such a man should either have, or acquire, a general knowledge of the technical part of the business and impart such knowledge as is necessary to his solicitors. We have found it good practice to hold weekly meetings of all solicitors and at these meetings to have either the manager, superintendent, head of the meter department or various other employees make an address. A meter is taken apart and its workings explained; an arc light is shown and the solicitor taught how it works; a motor is tested and the men see how it is done. This gives them a general knowledge of how electricity is measured and for what different purposes it is used and interests them more thoroughly in the work of selling the product. We have found that this interest on our part in the solicitors results in "enthusiasts," and enthusiasts generally "deliver the message to Garcia."

House-to-House Canvass

A method which we have found effective is to have a canvass made by the solicitors (house-to-house) of every place within


SOLICITOR'S REFERENCE

Address

Name ... Business

Gas { Installation ... arcs ... Wells ... Av. mo. bill $

Electricity { Installation ... Av. mo. bill $

Is place wired? Partially—Completely ... hours of usage.

Will party use electricity exclusively? ... Will party use Gas?

Power: ... Average cost per month, $

For what purpose?

Street service

Party is favorable—unfavorable for about

Is house rented or occupied by owner? ... Owner's name

Will party use an electric sign?

Remarks

See again on or about

Date ... Signed

Exhibit I

the vicinity of the company's lines or of probable extensions. These cards (see exhibit No. 1) are filled geographically in a suitable cabinet, and when the canvass is completed, the card cata-

logue furnishes a record of every house near the company's lines, whether they use electricity or not. By means of small clips of various colors and placed at various points on the edge of the cards these cards are filed as follows:

(1) Secured—Completely.
(2) Secured—Partially.
(3) Prospective—Immediate.
(4) Prospective—Of any date you may designate.

Business, residential and power prospectives are so arranged as to be readily separated.

The above are only the general divisions. Any combination can be secured by means of clips; for instance, many of the "par-

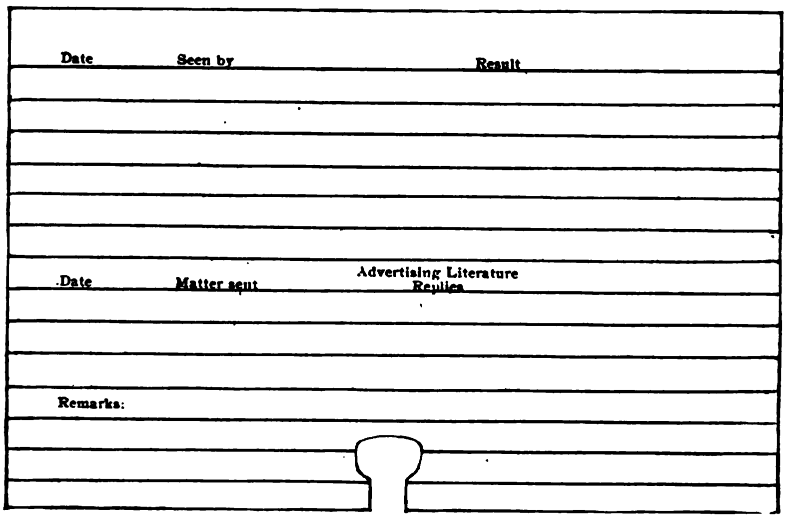


EXHIBIT 2

tially secured" may be those who have electric service for light and power, but have never used electric fans—a certain clip on the card indicates "party does not use fans." After these cards are once collected they should be kept up-to-date and systematically followed up. When a new customer is secured the clip on the card should be moved, or its color changed, so as to indicate "secured" "completely" or "partially" instead of "prospective," and, again, when a customer is disconnected for any cause

whatsoever, the position of the clip should be changed so as to indicate "prospective" (of any date) instead of "secured." If this system is properly followed up it furnishes at all times a complete record of the entire city and enables a manager to see at any time the amount of available business and how effective the soliciting department is in reducing the list of "prospectives" by adding to the list of "secured." It is also invaluable as an up-to-date list for use in connection with a "follow-up" advertising campaign.

Note the reverse side of card (exhibit No. 2). Here a record is kept showing the number of calls made and the solicitor who made them, as well as the result; also a record of all advertising matter sent, what was sent and the result. The last-named data enable one to see just how effective an advertising campaign is; and it is needless to say an advertising campaign can be made effective if properly looked after, while an enormous amount of money can be wasted on it if handled injudiciously.

Regarding Large Power Business

In going after large power business a central station is enabled to quote a low rate by contracting with the consumer to "keep off the peak." If such an arrangement is made you can sell electric energy at much less than your average cost of production and still make money out of the business. A good method of rating such business is to make a readiness-to-serve charge, depending upon the maximum demand, as indicated by curve-drawing instruments, plus a charge for electric energy as recorded by wattmeters.

Free Signs

We have succeeded in building up an immense sign business in several cities (in one situation nearly 60 cents *per capita*) by having the company furnish, erect and maintain signs at a flat price per month on contracts varying from one to three years. We were at first confronted by the fact that the law forbade the erecting of signs across the sidewalk, but the city council and the mayor of the different cities recognized the fact that the electric signs light up the streets free, and in three cities in which we are associated an ordinance has been passed not only granting

permission for electric signs, but compelling parties who get the privilege to illuminate until at least 9.30 every night and have a certain number of lamps per square feet of sign surface. We have also been able to secure the privilege of suspending signs, under certain conditions, across the streets.

I have placed on the secretary's desk a book of photographs of electric signs which we have furnished our customers, which book shows how elaborate some of the signs are. We do not claim that these signs are given free; we frankly state to our customers that the cost of the sign is involved in the flat price which they pay, and we have had no difficulty with them on account of their knowledge of this fact. I submit (exhibit No. 3) copy of sign contract and (exhibit No. 4) copy of sign ordinance passed by the city of Knoxville, Tenn.

Free Wiring

Free wiring is something that should be handled judiciously and by skillful hands, otherwise large sums may be wasted. I am opposed to any plan that will allow any customer to have all his wiring done free by the local company. Such a customer rarely appreciates the work you have done for him and generally thinks that, having done so much *gratis,* you are afraid of losing him and is constantly threatening a cut-off, even if he has a period contract. However, a plan we have tried is this: The company offers to wire six outlets in a place (consumer paying for the flexible cord and sockets and all fixtures), provided the customer guarantees a minimum monthly bill of $1.00 for a period of one year; any extra outlets to be paid for by the customer. In one situation where this was tried the six outlets cost a nominal sum, and the results, from over a year's experience, are very gratifying. The number of premises secured in the above manner bring in a surprisingly large amount of business, the six lights originally installed serving the purpose of acquainting the people with the convenience of electricity, then, as the well-known advertisement says, "they cry for more."

Renting of Fans

In one situation fans rented at $1.00 a month have brought in a large fan business. This rental scheme has been in vogue at

this special place for a number of years and the superintendent reports that $1.00 a month during the season is more than ample to pay the interest and depreciation charge as well as repairs.

Information Card

Exhibit No. 5 is what we call our information card. This is furnished to every employee of the company, and a prize is offered every few months for the man who brings in information of the most value to the company. This card, you will notice, is

INFORMATION CARD

KNOXVILLE, TENN. ____________ 190__

To THE KNOXVILLE ELECTRIC LIGHT AND POWER CO.

Mr. ____________

____

____

____

____

____

Signed ____________

NOTE:—Write above any information concerning Company's business. (Post at Once)

EXHIBIT 5

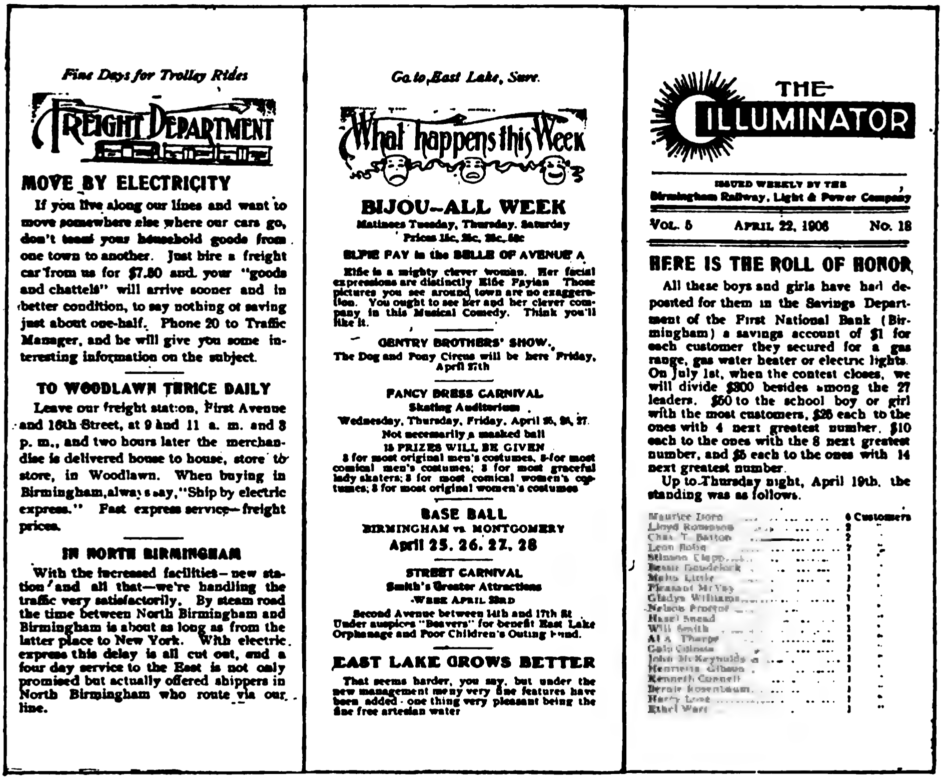
in the form of a postal, the object being to mail card at once, as notes made in memorandum books or on slips put in the pocket are frequently lost. Whether an employee is a meter reader or lineman, if he has any information that will result in the company's securing or retaining business, he makes note of same and mails card at once.

Enlisting the Aid of School Children

A novel method just inaugurated by one of our local managers is to enlist the aid of school children in bringing in business. A fund is deposited in a savings bank and it is advertised that for every customer brought on the company's lines by the aid of a school child, $1.00 will be paid the child. This $1.00 may be

used to open an account at the bank and thus start a savings bank book. From a few weeks' trial we believe that the results from this campaign will be very good.

(See exhibit No. 6, which also shows a sample weekly bulletin issued by the local companies distributed by being placed in pockets in the street cars.)



Fine Days for Trolley Rides

FREIGHT DEPARTMENT

MOVE BY ELECTRICITY

If you live along our lines and want to move somewhere else where our cars go, don't team your household goods from one town to another. Just hire a freight car from us for $7.50 and your "goods and chattels" will arrive sooner and in better condition, to say nothing of saving just about one-half. Phone 20 to Traffic Manager, and he will give you some interesting information on the subject.

TO WOODLAWN THRICE DAILY

Leave our freight station, First Avenue and 16th Street, at 9 and 11 a. m. and 3 p. m., and two hours later the merchandise is delivered house to house, store to store, in Woodlawn. When buying in Birmingham, always say, "Ship by electric express." Fast express service—freight prices.

IN NORTH BIRMINGHAM

With the increased facilities—new station and all that—we're handling the traffic very satisfactorily. By steam road the time between North Birmingham and Birmingham is about as long as from the latter place to New York. With electric express this delay is all cut out, and a four day service to the East is not only promised but actually offered shippers in North Birmingham who route via our line.

Go to East Lake, Sure.

What happens this Week

BIJOU—ALL WEEK

Matinees Tuesday, Thursday, Saturday
Prices 15c, 25c, 35c, 50c

ELFIE FAY in the BELLE OF AVENUE A

Elfie is a mighty clever woman. Her facial expressions are distinctly Elfie Fayian. Those pictures you see around town are no exaggeration. You ought to see her and her clever company in this Musical Comedy. Think you'll like it.

GENTRY BROTHERS' SHOW.

The Dog and Pony Circus will be here Friday, April 27th

FANCY DRESS CARNIVAL

Skating Auditorium
Wednesday, Thursday, Friday, April 25, 26, 27.
Not necessarily a masked ball
15 PRIZES WILL BE GIVEN
3 for most original men's costumes, 3 for most comical men's costumes; 3 for most graceful lady skaters; 3 for most comical women's costumes; 3 for most original women's costumes

BASE BALL

BIRMINGHAM vs. MONTGOMERY
April 25, 26, 27, 28

STREET CARNIVAL

Smith's Greater Attractions
Week April 23rd
Second Avenue between 14th and 17th St.
Under auspices "Beavers" for benefit East Lake Orphanage and Poor Children's Outing Fund.

EAST LAKE GROWS BETTER

That seems harder, you say, but under the new management many very fine features have been added—one thing very pleasant being the fine free artesian water

THE ILLUMINATOR

ISSUED WEEKLY BY THE
Birmingham Railway, Light & Power Company

Vol. 5 | April 22, 1906 | No. 18

HERE IS THE ROLL OF HONOR

All these boys and girls have had deposited for them in the Savings Department of the First National Bank (Birmingham) a savings account of $1 for each customer they secured for a gas range, gas water heater or electric lights. On July 1st, when the contest closes, we will divide $300 besides among the 27 leaders. $50 to the school boy or girl with the most customers, $25 each to the ones with 4 next greatest number, $10 each to the ones with the 8 next greatest number, and $5 each to the ones with 14 next greatest number.

Up to Thursday night, April 19th, the standing was as follows.

Maurice Dorn	6 Customers
Lloyd Robinson	3 "
Chas. T. Batton	2 "
Leon Rolfe	2 "
Stinson Clapp	1 "
Bessie Goudelock	1 "
Melvin Little	1 "
Pleasant McVay	1 "
Gladys Williams	1 "
Nelson Proctor	1 "
Hazel Snead	1 "
Will Smith	1 "
Al A. Thorpe	1 "
Gale Gilmore	1 "
John McReynolds	1 "
Henrietta Gibson	1 "
Kenneth Connell	1 "
Bernie Rosenbaum	1 "
Harry Lowe	1 "
Ethel Ware	1 "

Exhibit 6

RETAINING BUSINESS

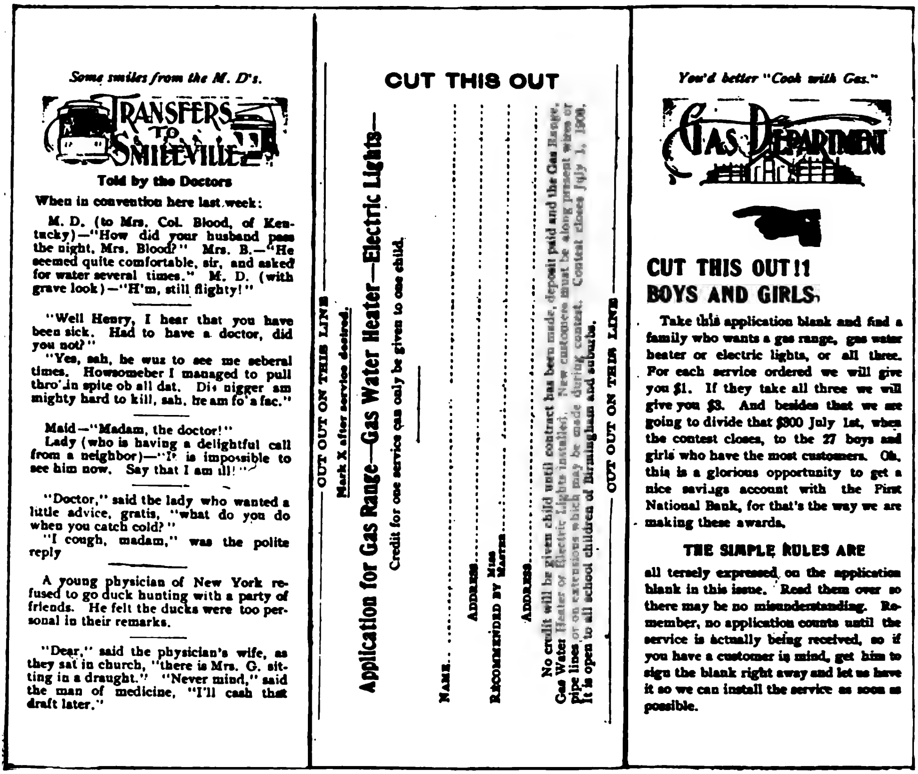
Eternal vigilance should be the watchword, with special attention to the following:

Good Service

This is absolutely necessary, and will do more than anything else to keep your customers.

An Effective Meter Department

Don't have bills over-read and under-read. Customers fail to appreciate the fact that such mistakes "even up" in the average —they want all bills correct. Have meters tested frequently, and know that they are correct to within a small percentage.



Some smiles from the M. D's.

TRANSFERS TO SMILEVILLE

Told by the Doctors

When in convention here last week:

M. D. (to Mrs. Col. Blood, of Kentucky)—"How did your husband pass the night, Mrs. Blood?" Mrs. B.—"He seemed quite comfortable, sir, and asked for water several times." M. D. (with grave look)—"H'm, still flighty!"

"Well Henry, I hear that you have been sick. Had to have a doctor, did you not?"

"Yes, sah, he wuz to see me seberal times. Howsomeber I managed to pull thro' in spite ob all dat. Dis nigger am mighty hard to kill, sah, he am fo' a fac."

Maid—"Madam, the doctor!"

Lady (who is having a delightful call from a neighbor)—"It is impossible to see him now. Say that I am ill!"

"Doctor," said the lady who wanted a little advice, gratis, "what do you do when you catch cold?"

"I cough, madam," was the polite reply

A young physician of New York refused to go duck hunting with a party of friends. He felt the ducks were too personal in their remarks.

"Dear," said the physician's wife, as they sat in church, "there is Mrs. G. sitting in a draught." "Never mind," said the man of medicine, "I'll cash that draft later."

CUT THIS OUT

OUT OUT ON THIS LINE

Mark X after service desired.

Application for Gas Range—Gas Water Heater—Electric Lights—

Credit for one service can only be given to one child.

NAME..

ADDRESS..

RECOMMENDED BY MISS / MASTER..

ADDRESS..

No credit will be given child until contract has been made, deposit paid and the Gas Range, Gas Water Heater or Electric Lights installed. New customers must be along present wires or pipe lines or on extensions which may be made during contest. Contest closes July 1, 1908. It is open to all school children of Birmingham and suburbs.

OUT OUT ON THIS LINE

You'd better "Cook with Gas."

GAS DEPARTMENT

CUT THIS OUT!!

BOYS AND GIRLS.

Take this application blank and find a family who wants a gas range, gas water heater or electric lights, or all three. For each service ordered we will give you $1. If they take all three we will give you $3. And besides that we are going to divide that $300 July 1st, when the contest closes, to the 27 boys and girls who have the most customers. Oh, this is a glorious opportunity to get a nice savings account with the First National Bank, for that's the way we are making these awards.

THE SIMPLE RULES ARE

all tersely expressed on the application blank in this issue. Read them over so there may be no misunderstanding. Remember, no application counts until the service is actually being received, so if you have a customer in mind, get him to sign the blank right away and let us have it so we can install the service as soon as possible.

EXHIBIT 6A

Avoid Special Rates

We make a statement that anyone is privileged to see any contract we make. Under the same conditions anyone gets the same rate, and we do not stretch our conscience to make a contract conform to this. A man feels "sore" against the company if he thinks his neighbor is getting better service than he is.

Study Your Rates

Try to sell your product to a consumer in accordance with

what it costs you to serve him. Most companies try to average rates by selling at so much per kilowatt-hour less discounts depending upon amounts used. You can not successfully sell in this way; if you try to do so, one customer pays too much in order that another may pay too little. What is the result? The man who pays too much is constantly on the lookout for a plant, or other methods of illumination, or other sources of power. We should also recognize that it is the long-hour burner—our most desirable customer—who pays too much on such an average rate system. In one situation we have adopted a rate for electric lighting at so much per kilowatt-hour for the first hour's average use of the installation; one-half of this price per kilowatt-hour for the second and third hours' average use and one-fifth of the first hour's price for all excess current. By such a rating a customer who uses his installation ten hours a day pays per kilowatt less than one-third the price that the consumer who uses his installation one hour a day.

Liberality

Be liberal in small things, like small repairs, and even in big things, like lamp renewals.

Prompt Attention

Attend promptly and courteously to all complaints. When in fault manfully acknowledge and make proper allowances. Moreover, a complaint, if just, is like a cancer—it needs the knife and not a porous plaster. Remedy the cause for complaint for all time, do not simply give a rebate or make some temporary arrangement; whether the complaint is on a bill or on the service, seek out the cause and remove it.

Politeness

Above all things, insist upon all employees being polite. Don't hire a boy 15 years old to answer your telephone and expect him to be, at that age, a Chesterfield. It pays to have a capable man or woman for that position. Remember that a customer does not know, or care much, who is the president or general manager of a company; the telephone boy, lamp boy and the solicitor are the "big ones" of the concern to him, as it is with them that he

deals the most. When I was a solicitor, I was considered "IT" by the customers and I do not know that I ever tried to persuade them to the contrary. If, therefore, men in subordinate capacities hold such an important place in the public mind, select the right men, pay them well and insist upon having from them the most courteous treatment of even the meanest and most ignorant person on the books.

EXHIBIT 3

Contract for Electric Sign Service

This agreement, made and entered into this the.................day of .... 190...., by and between the Knoxville Railway and Light Company, hereinafter called the Electric Company, and ....
.... of ....,
Tenn., hereinafter called the Consumer.

WITNESSETH, that the Consumer, in consideration of the stipulations and agreements herein contained, does covenant and agree with said Electric Company as follows:

1. Installation of Sign:—The Electric Company shall furnish ready for operation, at the premises of the Consumer, No. ....
.... in the city of ....
..............., Tenn., an electric illuminated sign of..................
.... type, described by the following sketch:

SKETCH OF SIGN

No. Lamps:—This sign shall have ....lamps of
.... type.

2. Ownership:—The sign and all fastenings and appurtenances shall be and remain the property of the Electric Company, and the same shall be removed by said Electric Company at the expiration of this contract, or in the event of abrogation of same or violation by the Consumer of any of the terms of same.

3. Permit from City:—The Consumer agrees to get, at his expense, the necessary permission from the proper City authorities to hang the sign or signs, as provided in this contract, and to pay any license that may be imposed for the maintenance or use of said sign or signs, and in event of failure so to do, the Company will not be held responsible for failure to hang said sign or signs, or for a removal thereof.

In the event of failure to get the necessary permission from the proper City authorities, the Consumer shall be liable to the Electric Company for the actual cost and expense incurred by said Electric Company in securing, equipping and construction of said sign and appliances.

4. Reinforcing Building Wall:—If it be necessary to reinforce or strengthen that part of the building to which the sign is attached, the Consumer shall pay the cost of such necessary work. The Consumer shall obtain permission for erecting the sign and attaching it to the building from the owner of the building and any other tenants who may be affected thereby.

5. Moving Sign:—If the Consumer desires the sign be moved from one building to another or that its position or location or fastenings be changed in any way, he shall pay all expenses caused by such change.

6. *Care of Sign:*—The Consumer agrees that he will not take down the sign or signs or loosen any of its fastenings, or permit same to be done by any one other than the representatives of the Electric Company; and, furthermore, that nothing shall be attached to or hung from the sign or signs.

7. *Renewal of Lamps:*—The Electric Company shall renew any lamps when necessary entirely at its own expense.

The Consumer agrees not to permit any one other than the authorized employees of the Electric Company to install any lamps other than those specified in this contract, and if he becomes aware of the fact that other lamps than these special lamps have been installed, he agrees to immediately notify the Company.

8. *Access to Sign:*—The Consumer agrees that the Electric Company's employees shall, at all reasonable hours, have free access to the premises for the purpose of examining, repairing or removing its property.

9. *Illumination:*—The Electric Company shall furnish current for the illumination of said sign during the hours specified in the following schedule, subject to the rules and regulations of the Electric Company, which are printed on the back of this contract, and made a part of this contract.

Schedule of Hours:

10. *Turning On and Off:*—The Electric Company shall turn on and off the current supplied to the sign.

11. *Service:*—The Electric Company agrees to use reasonable diligence in providing a regular and uninterrupted supply of electricity, but does not guarantee a continuous or uninterrupted service, and if said lamps fail to burn, or to burn properly, or if for any reason the Electric Company is unable to supply electricity, the Consumer agrees that the only liability of the Electric Company shall be to abate the rent for the actual time of no service. It is understood, however, that if the current is furnished at the sign or signs, but if some of the lamps fail to burn on account of being burned out, there shall be no rebate. The Consumer agrees to give immediate notice of defective service or burned-out lamps to the Electric Company's office. Burned-out lamps will be renewed from the Electric Company's storeroom, and will be furnished and installed by the Electric Company free of charge. Collectors, trimmers, solicitors and emergency men are not authorized to receive complaints, and the Company will not be held responsible unless complaints are made direct to the Electric Company's office.

12. *Payment:*—The Consumer shall pay to the Electric Company for the use of the electric sign and service herein described the sum of $.......................... per month. This amount shall become due on the first day of each month, beginning from the time the sign is first illuminated, but shall be subject to a discount of ten per cent if paid on or before the tenth day of the month succeeding that for which bill is rendered. The first payment shall be calculated on the basis of the fraction of the calendar month remaining after the sign is first illuminated.

13. *Term of Contract:*—This contract is hereby made for a period of .... beginning at the date sign is installed and ending ...., 19.....

14. *Extension of Contract:*—The term of this contract shall be extended for one year after the above-named date of termination, unless one of the parties hereto, thirty days or more before that date, gives written notice to the other party that he does not desire such extension. This process of extension shall be repeated until such written notice is given.

15. *Discontinuance:*—In the event from any cause whatsoever the use of sign is discontinued before the period as set forth in this contract expires, then, in that event, the Consumer agrees to pay to the Electric Company, on demand, the cost of the electric sign (pro-rated according

to the proportion that the unexpired period bears to the full term of contract) plus any expense the Electric Company may have been put to in erecting or maintaining electric sign. It is distinctly understood that this payment is to be considered as liquidated damages and does not give the Consumer in any way title to the sign.

16. Approval:—This contract, although signed, is subject to the approval of an officer of the Electric Company, and shall not be binding on the Electric Company until endorsed with its approval.

17. Final Agreement:—It is finally agreed that all the terms and stipulations heretofore made or agreed to by the parties in relation to the use of said sign or signs and the installation thereof are merged in this contract, and that no previous representation or agreements, made by the Electric Company's officers or agents, shall be binding upon the Electric Company except as and to the extent contained herein.

18. Charges:—The agreement between the parties hereto is completely set forth in the contract and none of its terms can be changed or modified nor any forfeiture under it waived save by an agreement in writing signed by the .... of the Electric Company, whose authority for this purpose shall not be delegated.

IN WITNESS WHEREOF, the parties hereto have caused their signatures to be hereto set, in duplicate, on the day and year first above written.

KNOXVILLE RAILWAY AND LIGHT CO.

....

....

ATTEST:

By ....

....

....Consumer

EXHIBIT 4

AN ORDINANCE

AN ORDINANCE REGULATING THE ERECTION AND MAINTENANCE OF ELECTRIC SIGNS ON AND ALONG THE STREETS AND MAKING IT A MISDEMEANOR FOR FAILURE TO COMPLY WITH THE SAME

SECTION 1—Be it ordained by the Mayor and Aldermen of the city of Knoxville, That it shall hereafter be lawful for any person, firm or corporation to erect and maintain over any sidewalk, across streets, avenues or alleys in the city of Knoxville, Tenn., illuminating signs as hereinafter prescribed in this ordinance, and for the purpose of this ordinance an illuminated sign is hereby declared to be any sign constructed as follows:

Signs of which all or any part of each letter is made entirely of metal, no wood being used in construction of letter proper, letters being studded in full outline with electric lights, or any solid metal sign with border of electric lights having no less than one and one-half lamp per square foot of sign surface. Signs to be wired according to rules and regulations of the Board of Underwriters of America, and in conformity with the regulations of the city of Knoxville. Wire to be rubber-covered and equipped with weatherproof sockets.

SECTION 2—Be it further ordained, That signs erected by authority of this ordinance, and overhanging any sidewalk, must be placed at least nine feet above the sidewalk and may extend their full width above same, and that no such signs shall commence a distance greater than two feet from the building, measured from the side of the sign nearest to it, while perpendicular signs may be set from the building to be clear from bay windows, and that both sides of all horizontal and perpendicular signs must be equally illuminated when they project over the street as above described; and that such signs erected by authority of this ordinance must be illuminated each and every night from dusk until the hour of 9.30 p. m., or longer, and on failure to comply with the said ordinance, the city shall cause those signs to be removed at the owner's expense. All signs erected across streets, alleys or other public highways, shall be at least twenty feet above the ground.

SECTION 3—Be it further ordained, That all persons, firms or corporations erecting signs under the provisions of this ordinance shall first obtain a permit to do so from the inspector of buildings, and the same shall be erected under his supervision, and the electric construction of same to be inspected and approved by the electrician of the city before the current is turned on.

SECTION 4—Be it further ordained, That if at any time any of the signs erected under this ordinance shall become defective, unsafe and dangerous to the public, the same shall be repaired or adjusted at the expense of the owner in such a manner as may be dictated by the engineer.

SECTION 5—Be it further ordained, That all persons, firms or corporations erecting, using and maintaining such signs shall save the city harmless from all damages arising from the erection, use and maintenance of the same.

SECTION 6—Be it further ordained, That any person, persons, firms or corporations violating any of the foregoing sections shall be guilty of a misdemeanor and subject to a fine of from $2.50 to $50, discretionary with the recorder.

SECTION 7—Be it further ordained, That all laws or parts of laws, in conflict with this ordinance be and the same are hereby repealed.

SECTION 8—Be it further ordained, That this ordinance take effect from and after its passage, the welfare of the city requiring it.

Passed third reading, November 18, 1904.

C. C. NELSON, Recorder.

Approved November 21, 1904.

W. H. GASS, Mayor.

AN AMENDMENT TO SIGN ORDINANCE

An ordinance amending an ordinance regulating the erection and maintenance of electric signs on and along the streets and making it a misdemeanor for failure to comply with the same; passed third reading November 18, 1904, and approved November 21, 1904.

SECTION 1—Be it ordained by the Mayor and Aldermen of the city of Knoxville that Section 1 of the ordinance regulating the erection and maintenance of electric signs on and along the streets and making it a misdemeanor not to comply with the same, be amended by striking out the words "one and a half lamp to a square foot" and inserting in lieu thereof the words "one lamp per one and a half square foot."

SECTION 2—Be it further ordained that Section 2 of said ordinance be amended by adding thereto the following: To these signs may be appended name of firm or brief description of business, provided this addition does not come within nine feet of the pavement as above provided for.

SECTION 3—Be it further ordained that Section 4 of said ordinance be amended by striking out the word "engineer" and inserting in lieu thereof the words "building inspector."

SECTION 4—Be it further ordained that all ordinances and parts of ordinances in conflict with this ordinance be and the same are hereby repealed.

SECTION 5—Be it further ordained that this ordinance shall take effect from and after its passage, the welfare of the city requiring it.

RULES AND REGULATIONS

REFERRED TO IN, AND MADE A PART OF, THE WITHIN CONTRACT

Original outfit of lamps furnished by the Company free.

The worn-out lamps must be returned in every case before a new one will be issued.

Lamps lost or broken by the consumer will be charged for by the Company.

Removal bills, special bills, bills rendered on vacation of premises, or bills rendered to persons discontinuing the service, must be paid on presentation.

In default of payment of bills within the time prescribed, the flow of electricity may be stopped until the bill is paid.

The Knoxville Railway and Light Company shall have free access into the premises for the purpose of examining the wires and lamps, or for the removal of any of their property. All wires, devices, meters, fixtures, etc., installed at the Company's expense, shall always remain the Company's property, and shall be peaceably yielded to the Company at the termination of contract.

In case the supply of current should fail, whether from natural causes or accident in any way, the Company shall not be held liable for damages by reason of such failure.

Contracts are not transferable. New occupants are required to make application in person at the office of the Company, at the time they commence the use of current, to avoid being liable for back dues for all current supplied until such notice was given.

No promises, agreements or representations of any agent or employee of the Knoxville Railway and Light Company shall be of any binding force unless the same shall be incorporated in the contract.

The consumer shall not permit access, except by authorized employees of the Company, to the meters and other appliances of the Company, or interfere with the same, and he shall provide for their safe keeping. In case of loss or damage to the property of the Company, from the act of negligence of the consumer or his agents or servants, or of failure to return the incandescent lamps supplied by the Company, the consumer shall pay to the Company the value of such property or the cost of making good the same.

When the deposit is waived, it is done in consideration of the agreement hereby entered into by the consumer to pay all bills at the Company's office for service rendered under this contract before 10th of the month; upon failure of which the Company reserves the right to exact a deposit and to cut off the current in case the deposit is not made.

The Company reserves the right, at any time, to cut off the current to prevent fraud or abuse.

The Company is merely a supplier of current deliverable at the main block of consumer's installation, and is not responsible for any damage to motors, apparatus or other property, or other damages due to wear and tear or inherent defects in the electrical installation.

No other electric service shall be introduced while this contract remains in force, without previous notice to and consent of the Company.

DISCUSSION

THE PRESIDENT: Mr. Scherck emphasizes one point that is coming more and more to the front—that of going after the larger consumers and giving them, necessarily, lower rates. This idea, I think, was put to his solicitors by Mr. Hale, of the Boston Edison company, in about as few words as it could be said. He remarked: "We are selling several kinds of kilowatt-hours. Some of our kilowatts cost us a dollar an hour and we perhaps get 20 cents for them; others cost us half a cent an hour and for these we get two cents. There is a good deal more profit in the two-cent-an-hour customer than in the 20-cent-an-hour customer."

These papers are now open for general discussion.

MR. FRANK W. SMITH (New York City): In Mr. Frueauff's paper he mentions the desirability of getting after very large business on low rates, rather than the small customers. It may be interesting to the members to know of a method adopted by our company to reach the small consumer at high rates. In the development of the upper section of New York City we have recently taken on a large number of apartment houses, for the elevator and hall-lighting service. These apartment houses were wired at the time of their construction, our only expense for connections being the placing of meters and lamps. We sent personally addressed letters to all of the non-users of electric light in these houses—getting their names from the hall boys, elevator boys, janitors, and so on. The first letter was followed by a second one. The result was that we received replies to the extent of nine per cent of the total letters sent, and of the replies obtained contracts for 75 per cent. We have connected in the last two and one-half months, by this simple business-getting method, approximately 6000 16-cp equivalent.

MR. M. S. SEELMAN, JR. (Brooklyn, N. Y.): In Mr. McGee's paper, on page 271, I find this statement. "We have found that the better way is to install a number of the articles, the sale of which we desire to push, in a number of carefully selected places where they will be seen and talked about; and that is, after all, the only result to be gained by advertising." Again, in the paper of the gentleman from Peoria (Mr. Wallace), I find a statement to the effect that advertising should be general, and that the only results that we can look for from advertising are general results. I disagree with both of these gentlemen. I believe that

the best results to be obtained from advertising, after we have once paved the way by this general advertising, are obtained by the advertising of specific propositions, and in connection with this I want to say that we in Brooklyn sell current—and I have no doubt it is done by many other large companies—directly as the result of our advertising campaigns directed along specific lines. We never send out any advertising—not one piece of advertising —without enclosing therein a return post card. We do not use postal cards, because postal cards are expensive and we have found by tests that the post card on which a one-cent stamp is placed by the respondent produced practically the same results with far less expense to us. We include post cards in every piece of advertising that we send out, and we get many practical returns from these post cards; not only in advertising general propositions, such as electric lighting, electric heating, electric power and electric fans, but for specific propositions, one of which I might instance.

We had an opportunity in Brooklyn not long ago to buy 1000 electric fans, and to buy them cheaply. We figured that the contractors in Brooklyn had not been doing what they should have done in the matter of selling electric fans, and we thought we could place a number of them on our system to far better advantage then the contractors could do. We bought the fans and advertised them by means of circulars, sending with each circular one of these return post cards. It was an experiment with us, inasmuch as we had not before done anything of the kind, and we did not know how many fans we could sell. Some of us supposed that we could not sell more than one-fourth of the 1000 fans, but in one month we had not only sold the whole 1000, but had sold 300 more. We had fixed June 1, as the limit of time within which the fans could be purchased, and by that date we had orders for more than 1300 fans and had to return a number of the orders unfilled. The point is that these fans were principally sold directly through advertising by means of the circulars and the return post card. The solicitors that we employed on that occasion went through the mails; it was a sort of mail-order proposition. The same thing applies to electric signs; and, in fact, to all, or nearly all, of the appliances that we are now marketing. The post card will help greatly in getting new business, so that the advertising with us means not only a general

method of education, but it means direct returns from prospective customers, and it is a good and cheap way of getting these returns.

In connection with the subject of retaining business—I was much interested in that because it is a subject I have looked into lately a great deal, and I was interested in all the suggestions of the various speakers as to the methods of retaining business. But there is one method that I have in mind which I have not seen mentioned in any of the papers presented here, which I think is advisable for all the companies, but especially the larger companies, and it is this: I think that the monthly bills—of course there are a number of companies that, no doubt, do this, but there are many that do not—that the monthly bills, either in the meter department or the billing department, should be compared, and if there is any marked dropping off in the bill of this month over the bill of the same month last year, if you wish, or in comparison with the bill of the month previous, or any other standard of comparison that you desire to adopt, then that case should be called to the attention of the executive officer or sales department of the corporation; the idea being that these are cases that, in many instances, if you let go will get away from you altogether. They are the cases where people are apt to be dissatisfied and have a grievance, and in large cities it is impossible to get through our solicitors any complete and thorough knowledge of these grievances; but if we follow the system I have indicated we shall catch the discontented man at once. As soon as his bill shows a marked falling off, send some one to see him, and if there is a grievance try to straighten it out. It has resulted in several stations that I know of retaining a good deal of business that would otherwise have slipped away.

Mr. John F. Gilchrist (Chicago): I was very much interested in Mr. Frueauff's paper, but I think Mr. Frueauff made one point rather strongly in it—perhaps more strongly than he intended. The inference I draw from this paper is that he advises in favor of going after good business and refraining from going after poor business, rather fending off the latter. I believe we have reached a position in this business where we must go after all the business we can get. Most all of us use differential rates, and they will, in a measure at least, take care of the difference between good customers and poor customers, but we must

remember that the man who is a poor customer is one of the factors in public opinion in our community, that he has a brain in his head and a vote on election day, and I feel that, while we should not neglect to analyze all business and go hard after good business, we should go nearly as hard after business we do not consider quite so good. We've had an illustration in Chicago during the last three months in our question of rate regulation by the city council. We were very much pleased to be able to show that we had quite a large number of customers on our system upon whom we were actually losing money, and it was a great element of strength to our position in the report of the committee —a very able committee, of which Mr. B. J. Arnold and our city electrician, Mr. Carroll, were members. The committee came out in its report, which was published, with the bald statement that the Chicago Edison Company and the Commonwealth Electric Company were serving a large number of their customers at a loss at the then existing prices, and intimated—I do not know whether this was in the paper or outside—that these customers represented probably as high as 25 per cent of the total number. The rates to which they referred were 16 cents for the first 30 hours in the month, and 10 cents per kilowatt for additional hours.

Mr. Wallace refers in his paper to the question of paying commissions to solicitors. I believe most thoroughly in that. We have been doing that in Chicago for two or three years; we started after hearing of the experience of the people in Brooklyn, the difficulty that we thought existed—that of getting the proper basis upon which to start the commission—having been overcome. We realized that if we paid the men on the basis of the 16-cp lamp, or some other unit, some solicitor, through no merit of his own, might get an office building or church and earn a big commission, while another solicitor, who might work much harder devoting attention to a smaller business, would get but little if any commission. We thought we might arrange it on the basis of income, as in Denver, but we felt that the difficulty of keeping track of it would hardly warrant the results. We believed a simpler method could be devised, and we got down to the basis of laying out for the solicitor the amount of business we expected him to get in a district, varying with the district; for instance, some of our down-town solicitors were expected to get 20,000

16-cp equivalents in the year, and in the outlying districts the solicitors were not expected to get over 3000 16-cp equivalents in the year, yet the man in the outlying district who might get only 3000 might do really harder work than the down-town man who would get 20,000. After he has secured that number in the year we pay him a small commission for each 16-cp equivalent, based on what he gets in connected load, and we pay him a larger commission per customer—one cent per 16-cp lamp, and in addition 50 cents a customer—after he has obtained his quota. This gave very good results on the yearly basis, but we found that many of the solicitors did not start on the year's work until July or August; they did not feel an incentive to begin sooner, as the commission was so far in the distance. We revised that during the past year, and now have it on a monthly basis. We found on an analysis of three years' business that we were getting a certain percentage of new business each month; six per cent in January and February, 10 per cent in March, 12 per cent in April, and May, a little lower in the summer months and higher again in the fall and winter. We divided the amount to be obtained into months—say the man's quota was 12,000 16-cp lamps per year; we divided it in that ratio, six per cent of 12,000 in January, and so on. The men who never earned a commission before now get a commission, and we do not pay the commission until the business is connected. It has resulted in the amount of business on our sheets between contracted load and connected load being reduced materially. The boys made every effort to get the business on the system, where it is yielding money, faster than they did before. No man can earn more than $200 per year in commissions. The men used to look on the commission as a sort of Christmas present when it was paid at the end of the year, but now it is paid every month, and they average $7.00 or $8.00 per month in commissions.

MR. W. H. GARDINER, JR. (Boston): I think there is a great deal of thought in what Mr. Gilchrist has just said. First, as to the selection or non-selection between profitable and unprofitable customers—I do not think that any of us worry about having unprofitable customers; I am quite sure we all have some of them. If any of us should get before a committee or a court of investigation, I think we should all undoubtedly be able to show that we have many unprofitable customers who are on the system for their own good, without any solicitation on our part.

As to what customers we shall seek, it seems to me that we should seek present or immediately unprofitable customers only if they can be developed into profitable customers within a reasonable time. I have in mind one situation, which was formerly competitive. The president of the consolidated company told me that the principal reason his company had been the successful one in the competition was that he had arranged a rate device which handed his competitor all the short-hour-burning, unprofitable customers, and took from his competitor all the profitable, long-hour-burning customers. The business and number of customers of the competitor was increasing with leaps and bounds, but its operating expenses were going up faster.

We have had here a symposium of new-business-getting which I think is a record-breaker. I was very sorry indeed that Mr. Scherck did not read his statements on the organization of a contract department, or tell us something more about it. In Mr. McGee's paper we have a very able statement of the situation from the point of view of the manager of a small company. The manager of a small company, I think, is very often apt to bemoan the fact that he has to attend to everything and has no assistants. I think that, from a certain point of view, he is to be congratulated on that fact, in that he thereby becomes personally acquainted with his customers and comes into personal contact with his entire situation.

Mr. Frueauff's paper is an epitome of the situation seen from the viewpoint of the larger companies, equipped with special salesmen in all the different branches and a large corps of distinct representatives and solicitors. In this problem it has been a great question in my mind as to just how far the duties and responsibilities of a district representative of a large company should go. As I said, the manager of a small company is to be congratulated upon his opportunity for coming into personal contact with all of his customers. The difficulty of managing a large company, in spite of the special salesmen, and so forth, is, I think, very great, because the heads of departments, the managers, can not get that personal *rapport,* that personal touch with their customers. This has brought up the question of extending the responsibilities of the district representative. The question is—shall the district representative be merely a man who goes and first sees that the present service is satisfactory as rendered, and then seeks to increase the use of the service by advocating the use of additional

apparatus, or by the more extended use of present installations, or shall he represent the company in the true sense more fully in most of the departments? Is he to be put in a position to adjust cases of high bills, to take effective steps to adjust the quality of the service and other causes of complaint that the customers may put up to him? In other words is he in a certain sense to become the manager of the company for the district that he represents? That involves, in a large company, an extremely intricate and difficult problem in organization as to the crossing of responsibilities and dividing of responsibilities, all of which is very objectionable. On the other hand, it brings about a sense of close touch with the customers of each district, so that when they are talking with the district representatives they are *de facto* talking with the general manager of the company for that district; of course always with the understanding that the final approval or veto rests with the heads of the company. I think this is quite a problem and is a fertile field for discussion.

There was another point in Mr. Gilchrist's remarks which I think is very interesting, and that is the question of flat salaries for solicitors *versus* premiums or commissions, and more especially the basis of the commission. As to net effective results, it seems to me that, other things being equal, the commission should be based on the net effective result we are after. I take it we are after net earnings, therefore, other conditions being equal, I should favor premiums or commissions based on net earnings rather than on connected loads. It seems to me that when we are basing commissions on connected load we are possibly premiumizing peak-building in our commercial department, and not premiumizing the real thing we are after in the business unless that initial connected load is capable of extension into long hours of burning. I think this is another question that may prove a field for discussion.

Mr. J. S. Codman (Boston): I am much interested in what Mr. Scherck says, on page 300, about avoiding special rates. It seems to me of great importance to have the rates of any company thoroughly well known and published, so that every one may know exactly what they are. In this way, many misunderstandings are avoided. I find very frequently, however, that this is not the case, as I have a great many times gone into the offices of electric light companies and tried the experiment of asking the application clerk for a copy of the rates. Very often I have

found that this request excites suspicion, or, if not that, it is at any rate considered an extraordinary request, and I have been told to see the manager. I would say—"Have you no printed copy of the rates that customers can look at and study at their leisure and decide whether they want to take current or not?" The answer would be—"No; nothing of the kind." Query—"Can you tell what the rates are?" Answer—"No, no; you will have to see the manager."

MR. FREEMAN: May I supplement the remarks with reference to the bonus basis of payment in addition to salary? It seems to me that there is a theoretical and a practical side to that question, just as there is to the rate question. The theoretical way to settle the rate question is to charge every customer in proportion to the cost of the service the company renders the customer. We find in practice that it is impracticable, and we must furnish customers—many of them—on a basis of loss because we must have rates that are clearly understood and are workable rates. I think the plan last suggested in the matter of the commission bonus is the correct one theoretically, but I believe we have got to adopt a practical method and waive some of the theory. I was very much interested in what Mr. Gilchrist said. I know he will forgive me if I say I thought that when he adopted the plan of paying the commission at the end of the year he was sacrificing the practical somewhat to the theoretical, and I notice he is going back to the basis of paying every month. I think, while this is a very interesting field for discussion, that we have got to come to a practical basis of paying our bonuses monthly without reference to the earnings we get from each customer. There is another reason for that. The commission is an incentive for the solicitor to exert his best abilities, and if you so complicate the situation that the solicitor has no earthly idea of what he is going to get out of the month's effort, it will not give him the incentive he requires. I believe the simplest method is the easiest and the most practical, and I believe we shall all be wise to adopt some simple and practical method, with the distinct idea that it does not work out fully along the lines of our theories.

MR. HAMMOND: I may be able to explain one of Mr. Frueauff's reasons for not wanting unprofitable business. Some years ago the Lacombe plant was a rival to the Denver company. It entered the field and promised many things. The Denver com-

pany at first treated it as a rival and, looking out for its own interest first, managed to turn over to the Lacombe plant such unprofitable business as it did not itself want. This point secured many new consumers. The total looked good, but the net result was not good, for it had secured only the unprofitable consumers of the Denver company. It is true, however, that unprofitable business can sometimes be educated into profitable business. In my opinion, you must treat each case alike.

The question of how to pay a solicitor is an important one. Mr. Doherty originated the scheme of paying them according to results. They get a certain salary and get a commission on the increased business over a year previous—each man being paid for what he does. Mr. Doherty found that this brought the best men to the front; and that is what a central station wants—its best men to the front.

The gentleman from the South has discussed franchises and how to secure them. I don't think you can use one general plan in any two cases. In Denver, we gave the public good service, fair rates, and had the good will of the vast majority. But a political complication came along. You must meet these cases as they come to the front. People with something to gain can make a lot of noise and trouble if they have the means. That was the case in Denver—a certain following wanted to be in power. They decided to use public utility companies to gain this end. They raised the question of municipal ownership. The mayor and members of the city council had investigated the lighting of other cities, and I think I am safe in saying Denver gives better rates and better service than any city of its size, or ten times its size, in the country. The Denver company, with all its good service, its good will of the public, had to go into the political field.

MR. C. H. HERRICK (Boston): I am especially interested in the merchandising and exploitation of what we have to sell. I think this subject should be pursued further, so that the members may have the benefit of all the information that it is possible to gather on the subject, and I should like to make the following motion: That a committee of five members be appointed by the president for the purpose of investigating, collecting and suggesting methods for the sale of electricity, such committee to report to the next annual convention, and to be called the *committee on exploitation*.

(The motion was seconded and carried.)

Mr. George R. Stetson (New Bedford, Mass.): We were recently under the necessity of analyzing the character of our constituency in the electric-lighting line, and found that fifteen of our customers paid us more money than four hundred of the household class, and the necessity of this analysis came from the four hundred, who paid less than the absolute cost of their service. This is the difficulty of arranging rates satisfactorily to all concerned.

In regard to the methods of estimating costs in our city, as established by the commissioners, the cost of furnishing a customer is between $20 and $30, and the majority of the four hundred mentioned are paying less than $1.00 per month. There might be a criticism on our method of promoting profitable customers among our householders. It is quite a proposition to know how to adjust rates under conditions of this character. There is no difficulty in taking care of a customer who burns long enough and uses a considerable quantity of current—you can afford to meet him on almost any conditions—but trouble comes with a residence customer whose use is so small as to amount to a less sum than is considered by the government to be the cost of his service.

Mr. Harold Almert (Chicago): I wish to say a few words in regard to Class A members in towns of 5000 or under on this new-business-getting proposition. At the January meeting of the Northwestern Electrical Association, in Chicago, I stated that I marveled at the lack of progressiveness and enthusiasm on the part of the managers. This was resented by some at the time, but I know the statement is correct, and some of the manufacturers are trying to get after stations of this class. I think the difficulties that a large number of the stations represented here are experiencing in adverse legislation are due to the lack of enthusiasm and progressiveness on the part of the small companies. I stated at the time that from observation of a number of these small stations that I get into in the course of the month, the managers, due to attacks from politicians endeavoring to ride into office, hungry newspaper men looking for write-ups, had been subjected to these attacks to such an extent that they had got into their shell and closed it behind them, and that any citizen or prospective customer who called was usually re-

ceived in a dingy corner of the plant which was not occupied by machinery, the desk was a dirty one, littered up with all kinds of junk, and the illumination in the evening was usually from a discarded lamp and receptacle from some consumer's premises, screwed in a very temporary manner on the window casing, or something of that sort.

I mention this simply to bring forth the statement I made at that time, that the marketing of electric light and power, even among the small stations, is no different from that of any other commodity. You have got to show it up to advantage the same as any other merchants do their wares. You should have a neat office, in a prominent place, be it ever so small, and should keep it clean. The office is the face of the corporation, and that at least should be kept clean if the rest of the plant is not. The manufacturers have realized this lack of progressiveness on the part of these small central-station men, but have kept quiet all this time in the hope that sooner or later the managers would wake up and realize the situation, but as they have not done so there has been formed the co-operative association which is arranging suitable doses of information to inspire this class of members; and I believe that this association should make a special effort to reach this class of members and educate them and bring them to a realizing sense of what their influence is. If this is done a good deal of this adverse legislation and municipal ownership agitation, to which we are subjected in the larger companies, will be met in a very desirable way. I believe that the manufacturers, in sending out information on how to get new business, instead of dealing in glittering generalities should give more concrete statements of how these little fellows can get at this class of business, by giving more detail costs.

In the papers brought forward here you must realize that in the small central stations all these various specialists of the new-business-getting department must be embodied in one man. He must be the whole works, as I do not believe it will pay to engage solicitors for any plant in a city of less than 5000 population, as a rule.

THE PRESIDENT: We will now take up the paper on *Free Electric Signs,* by Mr. John F. Gilchrist, of Chicago, which will be read by his brother, Mr. J. M. Gilchrist.

Mr. Gilchrist read the report, as follows:

ELECTRIC SIGNS

THEIR FREE INSTALLATION AS A FACTOR IN CENTRAL-STATION PROSPERITY, AND A REPORT OF ELECTRIC-SIGN CONDITIONS IN THE UNITED STATES

To the Members of the National Electric Light Association:

Gentlemen—During the last few years the increase in the use of electric signs as a means of advertising has been extremely rapid, so rapid in fact, that it has been almost impossible for the managers of the different lighting companies to keep in close touch with the development. The increase has been due to so many causes, and the efforts on the part of the lighting companies to encourage installation have met with such varied degrees of success, that the need of a comprehensive paper, dealing with electric-sign conditions in all parts of our country, is apparent.

The actual experience of practically all the central stations and the proportionate results from their expenditures of time and money for the development of the electric-sign business, should prove of practical value to every man in the association.

Realizing, however, that most of us especially desire to find out what success has attended the efforts of central stations supplying populations relative in size and with similar conditions to ours, I have divided the conclusions based upon actual conditions into four groups; towns under 10,000; towns between 10,000 and 20,000; towns between 20,000 and 50,000, and towns over 50,000—and in this way hope to come fairly close to every one.

It may be interesting to note at the outset, that of the 3300 lists of questions sent to the central stations for data, 1188 were filled out and returned. The exact figures of the answers returned are 882 from cities under 10,000; 107 from cities between 10,000 and 20,000; 127 from cities between 20,000 and 50,000,

and 72 from cities over 50,000. The conclusions given in this paper are based mainly upon these answers, supplemented by the writer's own knowledge of the field and conditions.

A conservative estimate of electric signs in the United States

FIG. 1—TWO SIGNS AT CHATTANOOGA WHERE THE LIGHTING COMPANY HAS ENERGETICALLY PUSHED THE SIGN BUSINESS. LARGE VERTICAL SIGN ABOVE AND SMALL PANEL SIGN BELOW

places the number at 75,000, consuming an average of not less than 480 watts per hour each or a grand total of 36,000 kilowatts per hour. At an average of eight cents per kilowatt-hour the hourly income from these signs would be $2880, the nightly income (averaging four hours per night) would be $11,520, and

the yearly income a total of $4,204,800. The vital question for each one of us is, what share are we getting of this tremendous volume of business, and how can we get more?

Keeping this income and its relation to us in view, let us ex-

Fig. 2—Three More Chattanooga Signs

amine some of the data given in the answers received. The total population of the towns under 10,000 was 2,885,942, and the total number of signs was 1971, making a sign to every 1464 people. In the towns between 10,000 and 20,000, where the total popula-

tion was 1,468,345, there were 1112 signs, or one sign to every 1320 people. In the towns between 20,000 and 50,000 there were 2198 signs to 3,205,493 people, or one sign to every 1458 people, and in the large cities of over 50,000, with a total population of 16,228,984, there were 18,682 signs, or one to every 870 people.

The following table summarizes the matter:

	Total Population.	Total Signs	Installed in 1905	Result of Lt. Co.'s Solicitation	Average Sign to People	Best Sign to People	Poorest Sign to People
Towns under 10,000	2,885,942	1,971	960	585	1 to 1464	1 to 75	1 to 10,000
Towns between 10,000 and 20,000	1,468,345	1,112	538	532	1 to 1320	1 to 200	1 to 15,000
Towns between 20,000 and 50,000	3,205,493	2,198	993	1,151	1 to 1458	1 to 350	1 to 23,000
Over 50,000	16,228,984	18,682	6,533	11,548	1 to 870	1 to 331	1 to 15,833
Total	23,788,764	23,963	9,024	13,826	1 to 988		

Please note the wide difference between the installation figures in the towns and cities where the sign business has been best developed, where of average development, and in the poorly developed places. Compare these best figures and apply them to your own town. In short, what would it mean to you in income if you had one twelve-light sign to every seventy-five people as one town showed? Would it not be worth all the thought and effort you could spend?

From the information obtained the inference is that each central-station manager thinks he has about all the sign business that can be obtained. Why is it, therefore, that some central stations have a sign to every seventy-five people while others have none at all or perhaps one to many thousand people? In every business there is a reward for energy and other business qualities, but surely there must be some peculiar conditions or elements behind these figures to cause so great a difference in the ratio of signs to population.

Yes, there are. A few central stations discovered, after studying the situation, that this class of business more than any other warranted encouragement. Other forms of their business, like plums and peaches, made a fairly good showing if left alone; the electric-sign business, like the apricot, had first to be created, next cultivated, and then given careful attention. But the first experiments proved conclusively that this cultivation paid big returns, if carried out along the right lines. Many men think they are doing this cultivating along the right lines when they

talk up signs a little or possibly put out a sign for themselves, but it can be put down as a fact that no central-station manager who has failed to put into effect some plan to eliminate the first cost of the sign to the consumer has begun to encourage the sign business.

"Free signs," you say. Yes—free signs—and, on any well-worked-out basis, the name "Free" was never a greater misnomer. After all, your sign is only one step in placing your product in your customer's hands in a usable shape—a little poorer form of investment than your engines and dynamos, equal to your lines, much better than your arc lamps, that is, if you use a good sign. You can buy signs that don't come in this category, but then you *could* buy wooden arc lamps, so when there are on the market signs made of such material and of such construc-

Fig. 3—Street Scene in Newark, N. J.

tion that they constitute good permanent investment, the electric-sign proposition should not suffer from the experience of those who have used poor judgment in the selection of a sign for such use.

Probably every one present understands the free-sign proposition, but for the benefit of those who have not thought about the matter, it should be stated that there are two propositions largely used by the different lighting companies. One is for the lighting company to buy the sign, and to install it free for a customer, provided the latter agrees to burn a minimum amount of current per month, and for a certain length of time. The amount and time are fixed so that the lighting company is justified in making the expenditure for the sign. The other proposi-

tion is for the lighting company to charge a flat weekly or monthly rate for the use of the sign and current. This rate also is sufficient to pay for the current consumed, about 20 per cent per annum on the initial investment in the sign, and any other expenses incidental to the proposition.

At the present time ninety-six of the 1188 lighting companies answering my questions are using one of these two free propositions and, except in a very few cases, are extremely favorable to it. These ninety-six towns, with a population of 10,047,-648, have 12,000 signs, or one sign to every 837 people, while the remaining 1092 towns, with a population of 13,741,116, had 11,963, or a sign to 1149 people. The general effect of this method of encouragement is decidedly apparent.

The thought at once arises that the very large cities probably bring this total up to such large proportions. But this is not true, as the following table shows. In fact the large cities have a lower percentage of signs to people than the small towns:

	No. Using Free Proposition	Total Pop. of Same	No. of Signs	Signs to People
Under 10,000	33	132,852	305	1 sign to 435
Between 10,000 and 20,000......	14	309,900	430	1 sign to 720
Between 20,000 and 50,000......	31	712,000	1,100	1 sign to 647
Over 50,000....................	18	8,892,866	10.165	1 sign to 874
Total	96	10,047,618	12,000	1 sign to 837

NOTE—A number of companies failed to answer this question.

While this showing of central stations using some free proposition is fairly large, it does not adequately express the sentiment on the subject. Nearly half of the central stations without any free proposition at the present time reported that they were very favorably inclined toward them, and were seriously considering the adoption of one of the two plans. For those about to enter this "free" field a sample contract form is reproduced at the end of the paper.

As one writer has expressed it, "The free proposition is the main pole in the tent which gathers under its cover all prospective sign customers. Without it the whole tent may fall to the ground unless those underneath stay and support it, which of course you can not depend upon them to do. All other forms of encouragement serve merely as side guys and make the protection more satisfactory to those already in and enticing to those without."

A number of forms of encouragement which have an important effect upon the success of the sign business are grouped and termed "Sign Service."

The main forms of this service are: proper hanging, keeping the sign clean, lamps renewed, sign in repair, and turning the current on and off.

Hanging

With all due respect to your different superintendents, not one in a hundred appreciates the business-bringing power of a sign properly hung in every respect. Even if this one service in no way affected the growth of the business it would pay you, as a means of holding customers, to see to the proper hanging of every sign on your lines. The sight of a sign attached to the building with substantial wall brackets and irons, with edges perfectly level and position correct, supported by the strongest chain, with neat chains and turnbuckles for side guys instead of wire, not creaking with the wind and as solid and safe as a rock—such a sight, I say, makes the other fellow want a sign. Will it not pay you, therefore, to do or superintend the hanging, not necessarily free, but at least giving full value to the customer?

Cleaning

The candle-power efficiency of a lamp is greatly increased by keeping the reflecting surface behind it bright; the lamp itself clean. This means that on your free proposition small-candle-power lamps light up the sign in good shape, and you are able to offer a price which seems low to the consumer and yet gives you a good return per kilowatt-hour; for the customer, in deciding whether or not to accept your proposition, doesn't worry about the candle-power furnished, but rather will advise you that he wishes a sign like his neighbor's, which looks very bright and attractive to him.

Furthermore, a bright, clean-looking sign is of more value to the merchant, giving a neat, business-like look to his store, which will mean a renewal of his contract when it expires. Lastly, a bright sign like "proper hanging" means more signs. Certainly nothing is much less attractive than a dirty, uncared-for sign. A certain large light company with a liberal free proposition and an efficient sign service in connection with it.

tried the experiment of cleaning the sign, renewing lamps and making small repairs free of charge on all the old signs that had been on its lines before their free proposition had gone into effect. Many of these had burned irregularly for some time, others did not even make a pretense of burning, having become badly out of repair. All were dirty and were a big drawback to the effectiveness of the company's free proposition. A careful

FIG. 4—THE READING CHANGES FOR EACH ATTRACTION. A VERY POPULAR TYPE OF SIGN FOR THEATRES

record was kept and it was found that the increased current consumed by those signs, with full number of lamps always burning, paid the cost of the service, to say nothing of the advertising value of clean, well-kept signs.

Renewing Lamps

It is a great detriment to the sign business to see burned-out lamps on a sign. Make a burned-out lamp the rare exception.

Repairing Signs

Here, again, it is important that you take the matter in hand. As most of you fully realize, some makes of signs are very rarely out of repair, and while the best way to settle the repair question is to pick the right make of sign, some trouble is bound to arise. Merchants will often allow a sign to remain out of repair when it is a very simple matter to fix the trouble. You should make it your business, for the sake of the additional revenue, to see that all small repairs are made at once. Besides, there is the other important element of impression on prospective sign users.

Turning Current On and Off

Turning the current on or off is a service that will increase electric sign patronage to an appreciable degree, and has an especial bearing upon the renewing of contracts. If the light company has a large number of signs the matter is a simple one, for the cost per sign of the patrolling is very low. Where a company has this policy, it is desirable to have two specified times for termination of the evening's burning, such as ten and twelve o'clock. In towns where signs are few and far apart, or are to be switched on and off at many different times, the time clock may be used, although not particularly satisfactory. In general, the value of this kind of service can readily be seen, inasmuch as a sign owner can not very well or will not attend to these small matters for his one sign, and they mean a trouble and expenditure out of all proportion to the value and nature of the service rendered.

It can be safely stated that where the company's sign business is or has prospects of being of considerable size, it is not only desirable but necessary to employ each and every one of these "service" forms. In the smaller-sized towns it may not pay to take up all these forms of service, but no town is too small to make the repair bill as small as possible, to renew lamps see that the signs are hung properly and to keep them clean. Where these seeming courtesies are extended, the prosperity of the sign business is great. The exact effect of each form of service, however, is not known, as the service is given largely in connection with one of the free propositions or to supplement some other special proposition.

The following table, figured from the answers received,

while it does not show how far it might be profitable for the different central stations to go along these lines, indicates what they are doing now:

	Hanging Proper	Cleaning Signs	Renew Lamps	Repair Signs	Turning On and Off
Under 10,000	30	19	219	30	27
Between 10,000 and 20,000	19	20	78	26	18
Between 20,000 and 50,000	38	34	101	41	37
Over 50,000	28	28	65	29	30
Total	115	101	463	126	112

One inducement which many central stations are making is a special sign-current rate. Some central stations even prefer this to a free proposition, on account of the absence of any financial investment. This is good so far as it goes, but the argument is poor. In the first place, the net income from signs is much lower in towns with only a special current rate than in the free-proposition towns, as our figures will show. It's the old question of capital. The small dealers—and right here let me state that these smaller stores make up the bulk of the sign business in the United States—these men either do not have the capital or will not risk from $25 to $200 or $300 of their reserve fund in an initial investment of this kind. It is this class of trade for whom the free proposition was created and to whom it appeals. These small merchants have been known to pay a flat rental of from $8.00 to $10 a week where they could not be induced to buy a sign at any price. In short, they wanted a good sign, but couldn't afford to or wouldn't buy it outright. But the bulk of these small men can be induced to pay from $1.50 to $6.00 a week in flat rates (which include the cost of the sign) if the sign is furnished free.

Furthermore, the flat rate means a steady *late* burning of practically all the signs on your lines, whereas, with a special current rate on meter, the owner may burn the sign chiefly at the peak. Even with a minimum burning clause, or rates graded according to quantity used, this can hardly be avoided and without such a clause the bill may amount to very little, whatever there is, however, being used at the peak. In other words, an electric sign owned and controlled by the merchant brings in approximately half as much income as a sign installed on any good "free" proposition, and yet requires the same central sta-

tion capacity. Don't think, therefore, that because your special-rate proposition has increased your sign installation, you have developed the field.

Sometimes the special rate is in the form of a sliding-scale discount, based on the quantity consumed. Often it is a flat rate per lamp per week, the rate depending, of course, upon the

Fig. 5—Showing the Type of Store the Proprietor of Which Can Be Induced to Use a Good-Sized Sign. This Hustling Little Storekeeper Is Well Satisfied with His Investment

candle-power of the lamp and the specified hours' burning. (This is very good.) The special rate mostly, however, is a straight reduction of from 10 to 50 per cent in the rate per kilowatt-hour.

Of the total 1188 stations, 158 made a special current rate for electric signs with an average reduction of 38 1-5 per cent.

Thirty-nine of these had free propositions, and in these towns there was one sign to every 730 people. In the remaining 119 towns without free propositions, there was one sign to every 800 people. This, however, is not a full comparison, as income is what the station is interested in, and the income under the flat-rate free proposition is much more per sign per year than under other circumstances. Seventy-two towns under 10,000 made a special rate; thirty-seven towns between 10,000 and 20,000; thirty-four between 20,000 and 50,000 and sixteen towns over 50,000, showing fairly even distribution. (The figures above show that the effect of the special rate, while better than the average, is below the effect of a good free proposition.)

Another popular method of encouraging installation is for the lighting company to have the sign billed through them and thus give the retail sign purchaser the benefit of their dealer's discount. Still other methods are to connect or hang the sign free or at lowest cost of materials and labor. In other words, it is necessary and desirable for the central station to show that it is ready to co-operate in every way possible by helping to bear the initial financial strain and by giving thorough and efficient service.

A certain number of companies have experimented with the plan of allowing the portion of the flat rate above the cost of the current to apply toward the payment for the sign until the sign becomes the property of the customer. On the face of it this looks like an extremely liberal proposition and one calculated to increase the business, but it can be said positively that while this may work out to the advantage of the light company in one or two individual sign cases, as a policy it is a flat failure. It has been shown that as soon as the merchants own their signs the station has no further control and their current bills immediately drop. Inasmuch as just as many merchants can be induced to accept one of the regular free propositions, a more liberal proposition which results in a final unsatisfactory condition would certainly be extremely foolish.

All these propositions, however, will mean nothing if the prospective sign customers are ignorant of them. It is one thing for the central-station contract agent to know that he will make certain concessions and inducements in favor of electric-sign users, and another thing for the man who might thereby be in-

fluenced to put up a sign to realize these facts. One central station manager with a liberal "free" proposition complained that but two signs had been installed on that basis and that the propositions didn't work. Yet he answered that he had made no special canvass since the proposition had been inaugurated, had done no advertising of any kind and did not even have a sign at his own office. How could he expect the scheme to be a success?

FIG. 6—THIS SIGN, WHICH IS STILL IN GOOD CONDITION, WAS ONE OF THE FIRST OF ITS KIND INSTALLED IN CHICAGO (APRIL, 1902). IT ILLUSTRATES THE DURABILITY OF THE MODERN SIGN

No one knew about it. The questions of advertising and salesmanship, therefore, should figure very prominently in all plans for increasing your sign installation. They are not only important, but essential, for the average merchant not only does not realize what proposition you will make, but hasn't even thought of an electric sign. You must tell him of the value of

the electric sign in commercial life and thus start his mind in the proper channels, and then reinforce it by telling him again and again.

There are, of course, thousands of methods of putting the matter before merchants; as many ways, in fact, as there are advertising schemes and selling plans. It will be impractical in this paper to take up these different methods in detail, and furthermore somewhat unnecessary, as a great deal has recently been written upon the subject. A hasty glance at what some of us are doing or have done along this line, however, with special reference to the results obtained, will serve to show the value of proper methods. In the first place a total of fifty-three central stations are employing one or more solicitors giving part time to signs. There are only seven central stations in cities under 10,000 that have a regular solicitor giving part of his time to signs, but the results in those places would seem to indicate that other central stations in the smaller places could well afford to have a solicitor spending part of his time at least in this way. A much larger number of companies have made a definite canvass of prospective sign customers and the results here too would seem to indicate that where the company had a good liberal proposition behind the canvass it was successful. In some cases the canvass was successful without any special proposition at all, by simply educating the merchants in regard to sign value, but generally speaking it is preferable to have some definite proposition to present. Some few cases reported that with an extremely liberal proposition not a single sign was placed. These are rare exceptions, however.

An important element in determining the success or failure of a canvass is the supplementary advertising. After getting a complete list of all prospective sign customers, a letter or a card setting forth the value of sign advertising, and telling your proposition, will make the canvass more effective by many per cent, while a series of letters and cards will have a correspondingly greater effect. Some central stations rely entirely on a canvass, some entirely upon an advertising campaign. The wise central-station manager will use both.

Sixty-six central stations have advertised in the local papers for sign business, seventy-nine have used circular letters or mailing cards and thirty have used both. Ninety per cent of these

central stations had a definite proposition to present, offering some service, and the results were wonderfully favorable.

The following table shows what it probably will pay your central station to do. It shows, also, how little has been done in the last two years and how little the entire field has been canvassed. Keep in mind, however, that the figures were obtained from the 1188 answers received:

	Newspaper	Mails	Canvass	No Doing All Three
Under 10,000	12	19	106	4
Between 10,000 and 20,000	11	9	36	8
Between 20,000 and 50,000	21	17	45	3
Over 50,000	22	34	43	11

There is one other thing, which is a combination of salesmanship and advertising, and a very effective one at that. A central station should have at least one sign to advertise its own business. As the matter was very effectively put in some advertising matter recently distributed to the central stations, you can't expect merchants to put up signs unless you, who get the current at cost, take your own medicine. It is simply astounding how many central stations in this country, attempting to build up a sign business, are unwilling to spend $100 to demonstrate practically that they believe their own statements, and the deterrent effect of such a policy is very serious. But more than this, the prospect naturally wants to see a definite sample of a make similar to the sign he desires to order. Some of the medium-sized companies have as many as three signs—a large outlined-letter roof sign on the plant; an outlined-letter sign over the office and a border-light sign in some prominent place.

Oftentimes the panel sign will read "These Signs Installed Free," or some similar reading. In all cases the companies seem well satisfied with their investment, unless the signs themselves have proven mechanically unsatisfactory.

	Population Under 10,000	Population Between 10,000 and 20,000	Population Between 20,000 and 50,000	Population Over 50 000	Total
Number of central stations using signs for themselves.	72	47	32	70	212
Number of signs used by central stations	72	53	36	116	276

The difference between the number of signs and central stations is due to the fact that some companies have several signs.

The figures that have been given, up to this point, show that

electric-sign installation is in a prosperous condition, yet were it not for one hindrance these figures of prosperity would be largely increased. This stumbling block is the old question of sign ordinances and restrictions.

My investigation leads me to the conclusion that this is a phantom obstacle, as all but fifty-two out of the 1188 replying say that the council is either favorable or indifferent. It is a safe assumption, therefore, that the unfavorable councils need

FIG. 7—A SIGN IN BOSTON, INSTALLED BEFORE A HIGH-GRADE STORE

only to be shown what is being done in other cities and of what their policy is depriving them, to speedily enact a favorable ordinance.

As pointed out, there were fifty-two companies that reported harmful ordinances, but probably a number of those companies not heard from had some restriction which accounted for their lack of interest in the sign question. Here are some of the restrictions reported:

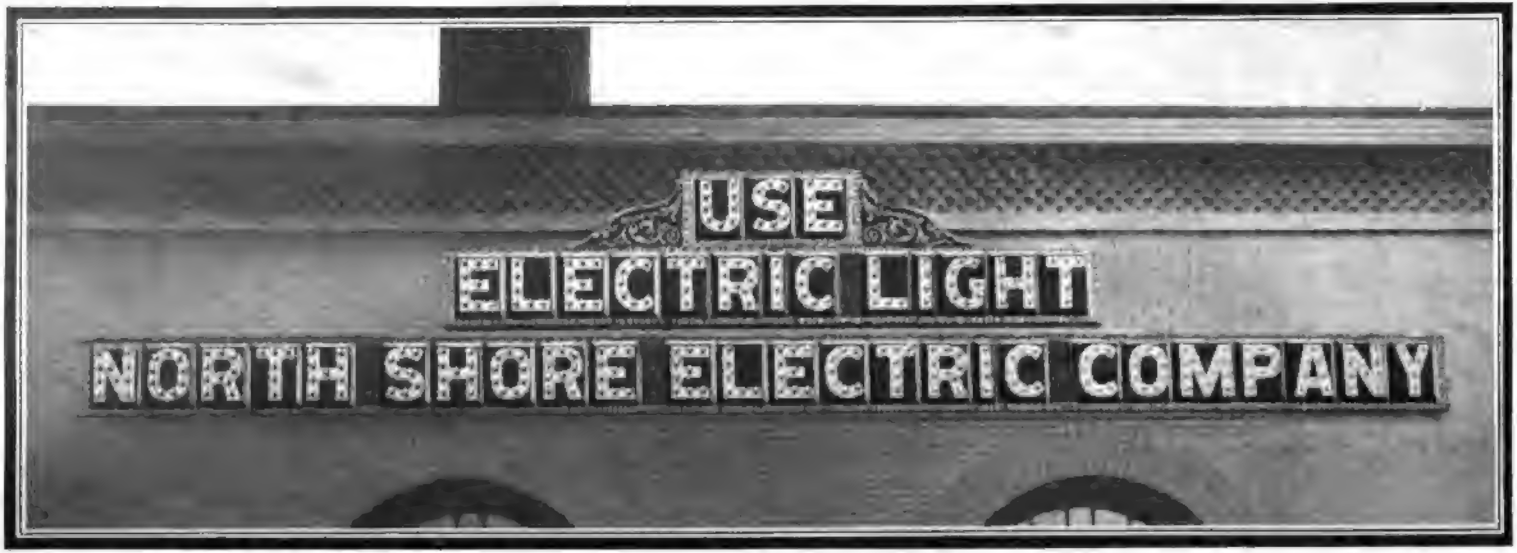


Fig. 8—An Extremely Effective Sign for the Plant. The Fifty Daily Trains between Chicago and Evanston Pass This, and Thousands of People See the Sign

Fig. 9—The Famous "HUB" Sign in Chicago. This Sign Is the Largest of Its Kind in the World, Having Space for Seventy 24-Inch Letters and Two Tremendous End Pieces. The Chicago Edison Company Furnished the Sign Free on a Flat Two-Year Contract. The Letters Proper Are Changed Every Week, Giving the Sign a Powerful Value for Every "Sale" and Season. In Addition, the Novelty of the Sign and Its Changing Reading Are the Cause of Much Newspaper and Other Advertising Publicity Beneficial to the Store in Question and to the Sign Business in General

No electric signs permitted to hang over the sidewalk—restricting the distance from the outside of the sign to the face of the building to less than three or four feet, usually one or two feet—a prohibitive fee or bond to the city, in a few instances many times the original cost of the sign—and prohibiting electric signs altogether in several cases, even flat against the building. A strict regulation as to wiring and hanging should not be considered a detriment, for it would hurt you more than any one else if a fire should be caused by defective wiring or construction of the sign, or should any one be injured in an accident resulting from improper hanging. For this reason, in submitting to your city council a tentative ordinance, put in sufficient safety clauses to make opposition on this score out of the question.

All those reporting deplored these adverse municipal conditions, and yet thirty-one of the fifty-two stated that they had done nothing to have the ordinance changed, just as if that were the end of it all. One or two stated that the time was not propitious. Admitting this to be true in a very few cases, does it not seem incredible that thirty-one central-station managers would calmly sit and let the matter of a sign ordinance rob them of the benefits of a profitable sign business? This is especially strange when so much can be done and has been done by others equally embarrassed along this same line. City and town governments are becoming more and more liberal every season, realizing as they do the advantages of electrical advertising. Did these changes take place from chance? Did the council happen to think of the matter? Perhaps in isolated cases—yes! But an examination of most of the cases will show that the lighting companies got behind and pushed, using all the influence and tact they had.

For the benefit of those who care for detailed information as to how some companies have proceeded in securing a change in adverse legislation, I would state that the cases which have come to the attention of the writer have been the result of educating the mayor or city council along the following lines: Showing that cities generally are becoming more and more favorable to durable and well-made electric signs provided they are carefully and properly hung; explaining that electric signs light up the streets of the city or town at the expense of the merchants and thus save the town money, besides serving as a direct source of

revenue in fees; showing that lighting the streets in this way gives the town a metropolitan appearance and brings in trade from the surrounding country districts.

Thoroughly endorsing these practical suggestions, the writer would advise that at about this stage a favorable ordinance be drafted and submitted to the council. Don't let them draft one

FIG. 10—EDISON PROGRESSIVENESS IN BOSTON HAS DONE WONDERS IN THE FACE OF A RESTRICTING ORDINANCE. ISN'T THERE AN OLD STACK IN YOUR TOWN THAT YOU COULD UTILIZE IN THIS WAY?

and then try to tear it to pieces. A man does not like to be told he's wrong. If possible, get a number of merchants to sign a request for the passage of this ordinance and to work for it. This will not only have the effect of helping to influence the

council, but you will have a number of merchants thinking they want signs. It's human nature for us to want something we can't get, and you will make prospective sign customers of merchants whom you could not have interested in any other way.

There is one important point in connection with the ordinance question which is often overlooked. Ugly sign-boards or board signs not electrically illuminated have been legislated against in a large number of cities for the reason that they have the disadvantages of electric signs without any of their advantages. They do not help to light the city. They very soon fade out, being common painted boards, and generally little care is taken in hanging them. Where there is no legislation directly against these boards, electric signs are likely to be classed in the same category in public opinion.

For the benefit of those directly interested in the drafting of an ordinance we print in an appendix an outline sample ordinance which may be of some service.

The question of income, which I touched upon in the early part of this paper, is the interesting one to most of you. We all have a philanthropic spirit to brighten up the streets with beautiful electric signs. If at the same time, however, we can increase our earnings, all the better. It reminds me of the advice of a college president to the graduating class when he said, "Young gentlemen, never marry a girl for her money, but don't be foolish enough to let the matter of a few millions deprive the right girl of the right husband." My advice, therefore, is, "Don't deny your city the privilege of enriching you, when you can give compensation for value received."

What net profit is there in the electric-sign business? It is easy enough to say that the gross income from electric signs last year was $4,204,800; but how much did it cost to get the business, to supply the current and to buy some of the signs and take care of them?

Examples showing the net income per kilowatt-hour from a given sign installed on the free proposition will best illustrate this.

The sign shown in Figure 11 is a double-face 16-inch letter sign reading "Drugs." The sign has eighty-eight sockets, weighs (complete boxed) 200 pounds, and sells for $73.50 f.o.b. factory.

Works Out on a Two-Year Contract as Follows:

Being constructed of durable material throughout, it is conservative to figure the cost to the lighting company in five years (putting out to new customers if necessary), including wiring and hanging, at $100, or $20 per year.

Flat-Rate Plan

Cost of sign to lighting company on two-year contract...$40.00
Burning for two years from dark to 10 P. M. (averaging four hours per night)........................2920 hours
88 2-cp (special 10-watt) lamps consume.....880 watts per hour

FIG. 11

Total current for two years equals 2920 hours × 880 watts, or 2569 kilowatt-hours.

At four cents per lamp per week your total revenue on a two-year contract is $3.52 per week, or.........................$366.08
The proportionate cost of sign for two years is............................ 40.00
Cost of complete supplementary service for two years.......................... 44.00
Net revenue for current (2569 kilowatt-hours) 282.08
Net revenue per kilowatt-hour........... .1098

At a higher or lower flat rate per lamp the return would be proportionately greater or less. For the purposes of the following comparison we are assuming that the average net income from current used by signs on the flat-rate free proposition has approximated over eight cents per kilowatt-hour, but the writer wishes to call attention to the fact that this plan offers an opportunity of obtaining a much higher rate even than the 10.98 cents per kilowatt-hour shown above, as the assumed price of four cents per lamp is exceedingly moderate. The proposition also offers an opportunity to those having a low established current rate, of obtaining as much from signs as they do from any other class of business—or more.

FIG. 12—THIS SIGN SHOWS ONE WAY OF EFFECTIVELY OVERCOMING A STRICT ORDINANCE RULE. THE SIGN, LOCATED ON A CORNER, IS READABLE FROM TWO DIRECTIONS

Minimum Monthly Burning Plan

Minimum required to be burned monthly (88 2-cp, 10-watt lamps)	107 kilowatt-hours
Rate for current	10 cents per kilowatt-hour
Minimum monthly income	$10.70
Total (minimum) income of two years	256.80
Proportionate cost of sign in two-year period	40.00
Cost of service (no patrolling)	16.00
Net revenue for current (2569 kilowatt-hours)	200.80
Minimum net per kilowatt-hour	.078

Assuming the above rates, the return of 7.8 cents per kilowatt-hour is the lowest possible return to the central station. If the merchant has used more than the minimum, the central station receives a higher return on a larger quantity of current. As in the flat-rate plan a lower rate will give a proportionately lower return. It is safe to assume that the average net return on this plan also is eight cents per kilowatt-hour.

On the signs put out as a straight sale proposition the rates average about eight cents or slightly more.

We can see, therefore, that the average for all sign current is slightly more than eight cents per kilowatt-hour. Assuming a cost delivered of three cents per kilowatt-hour for electricity, at the average load factor of an electric-sign load we have a full five-cent profit per kilowatt-hour. On the 52,560,000 kilowatts (estimated sign consumption) this would give a net income or profit of $2,628,000 per year. Inasmuch as an increase in installation means a decrease in expense of service and operating, increase in profits on future business should be greater than in proportion to connected load.

It is interesting to note what the total income from sign business in the whole country would be if all cities were as good as the best three towns in each population division. For instance: The best three towns among those under 10,000, with a population of 20,800, have a total of fifty-five signs and a total income from signs of $5139. The best three between 10,000 and 20,000 have a population of 45,000 and a total income of $15,-884.80 from 170 signs. In the best three towns between 20,000 and 50,000 with a total population of 95,000 there are 325 signs, bringing in an income of $30,400. In the large cities over 50,-000 the three best cities, with a total population of 373,865, have 1225 signs and a total income of $114,464. In choosing these towns we picked out those reporting the largest income per inhabitant from signs and not the largest number of signs.

Best Three	Total Population	No. Signs	Total Income	Sign to Population	Income per Capita
Under 10,000	20,800	55	$5,139.00	1 to 378	.24
Between 10,000 and 20,000....	45,000	170	15,884.80	1 to 264	.33
Between 20,000 and 50,000....	95,000	325	30,400.00	1 to 292	.32
Over 50,000	373,865	1,225	114,464.00	1 to 305	.30
Total	534,665	1,775	165,887.80	1 to 301	.31

Thus we see that with a total population of 534,665 in these twelve cities there were 1775 signs, or one sign to every 301 persons. The total income from these signs was $165,887.80, or 31 cents per inhabitant.

Let us suppose that of the 100 millions in the United States 60 millions could be supplied with current. At 31 cents per inhabitant, as an average, our total income from electric signs alone would be $18,600,000.

Think of it—$18,600,000! And yet this is not an impossibility and serves to show the great field before us.

It is estimated from information furnished recently by the United States bureau of statistics that the total gross annual income of electric-light companies is $112,248,807. If our figures of $4,204,800 for electric signs are correct, therefore, about four per cent of the total comes from electric signs. While this per cent isn't so very large of itself, considered in the light of extra current used mostly after peak, it is well worth going after.

So much for income. You, gentlemen, must do the rest. Many fortunes have been made on paper only to fade away through lack of proper development of the possibilities at hand. May the next convention see only smiling and prosperous faces.

A central station in a prosperous middle-sized town in Ohio writes:

"We have attempted to talk up the better class of signs only, believing that it will be better to work along a little slowly, installing good signs, than to attempt to fill up the business streets with cheap signs of small lighting capacities."

To a certain extent this may be sound reasoning, but the writer agrees with it only to the point of discouraging unsightly transparencies and signs illuminated by two or three lamps, which are not electric signs. Encourage your customer to use a well-designed and well-illuminated electric sign, but don't let him conclude to do without one because he can not afford to pay the cost of operating a 500-light sign. Remember that it is much better to have 1000 lights in forty signs than in two. In the first place, when you have but two large signs, an expired contract seriously affects your business, while in the large number of small signs new business will easily overbalance small contracts that may expire. More important still, however, is the fact that the possibilities for future business from the forty small consumers is far greater than from the two. Not only will many of them ultimately use larger signs, but the fact that their places are wired will lead to other lighting business. The argument has been made that in the smaller-sized towns the merchants can't afford to get expensive signs. True; but they can't afford cheap ones at any price. The solution of the matter is to encourage the best and most permanent type of sign, no matter how small it will have to be to meet the price the consumer can afford

to pay. Tell your prospective customer that while an electric sign will designate his place of business and perhaps show the line in which he is engaged, a large part of its value lies in the impression it makes. A sign should be considered as an advertising investment, and if its impression is not a good one the money thus invested is more than thrown away. An electric sign should lend an air of quality to a store, and it is this element which gives it greatest value.

What, then, are some of the essentials of a good sign? What points should the central-station man insist upon? In the first place the sign should be made of the very best materials and such care and simplicity be employed in construction that the sign will have *durability*. To have this durability, the sockets must be substantial and copper-shelled, the sign itself must be waterproof and the sign surface of metal or special material of a like nature.

In the second place the sign must be *safe*. This means that the wiring will not cause trouble; that the sockets will not short-circuit, that the hanging rig is safe; and, in short, that when the sign is once up it will stay up without danger of falling or fire.

In the third place the sign must have an attractive appearance and the surface be of a material that will not fade or lose this appearance. The sign must have *life* in it.

Lastly, and this is particularly important where the central station owns the sign on some "free" proposition, the sign must be *interchangeable* to such a degree that, should the customer for whom the sign is first purchased not renew his contract, it can be used for another customer at small expense, and this be accomplished without affecting the durability.

With a sign embodying these good points we can employ the methods suggested in this paper with a feeling of security that the signs themselves will do what we claim for them. Without a sign of this kind to back us up, all the propositions, advertising and salesmanship in the world will not be successful in the end.

To sum the matter up in other words, we must overcome the difficulties which seem to confront us by taking the initiative. If it's a sign ordinance, show why and how it can be changed. If it is apparent slowness on the part of the merchants, make a proposition that will give you something to talk about, and then

enforce and re-enforce "sign value" until they can't get away from it. Stick to the spirit as well as to the letter of your sign proposition, by performing the service in a thorough manner. If

FIG. 13—COLONIAL THEATRE, CHICAGO. THE READING FOR THE LOWER PART OF THE ABOVE SIGN IS CHANGED FOR EACH ATTRACTION

you are to clean the signs, keep them shining; if you are to renew lamps, do it promptly; if you are to keep the sign in repair,

never let it be out of repair. Your sign customers will be your friends, they will enthusiastically tell their friends and your sign installation will keep steadily advancing.

FIG. 14—THESE SIGNS ARE VERY POPULAR IN ST. PAUL

We have an opportunity here, gentlemen, to largely increase our business. It will take hard work—it may take a slight risk. What will the report be next year?

FIG. 15—TWO ARTISTIC SIGNS IN PHILADELPHIA

OUTLINE ORDINANCE

SEC. 1. Unlawful to erect and maintain any electric sign except as prescribed in this ordinance.

SEC. 2. An annual fee of ten (10) cents per square foot of sign surface for projecting signs, or three (3) cents per lamp for signs flat against the building, to be paid to the city to cover cost of inspection, and so forth. Temporary signs, fee one-quarter the foregoing.

SEC. 3. Permit to be obtained from city electrician for construction and installation. Upon completion, another permit approving work and for maintenance for one year. Special permit for any alterations.

SEC. 4. Signs must be hung at least nine feet above sidewalk; inside edge of sign to be not over 24 inches from the face of the building; outside not to be beyond curb line. No electric sign exceeding six (6) feet in length shall exceed half its length in width.

SEC. 5. In addition to the foregoing requirements, all signs must comply with the following:

MECHANICAL REQUIREMENTS

(DIV. A.) Materials of which signs are constructed must be rendered thoroughly waterproof and so constructed that they will not shrink or crack and thereby endanger the waterproof qualities which are required. Letters must be so constructed that sleet, snow or rain can not enter them.

(DIV. B.) The supporting cable or rod for signs must not be attached to or supported from wooden plugs; an approved toggle or expansion bolt must be used; or the rod to which the support is attached must be drilled through the wall and fastened on the rear side in a substantial manner. The side guys for signs must not be smaller than one-fourth of an inch in diameter.

(DIV. C.) Signs suspended over streets must have two individual attachments to each building or pole.

(DIV. D.) Each and every support for all signs must have a tensile strength of at least four times greater than required for the weight of sign, and subject to the approval of the Inspector of Buildings.

(DIV. E.) Signs weighing less than 100 pounds must have one main support attached to a bolt through the wall, having suitable washer plate, unless the supporting cable or chain is at an angle greater than 45 degrees, when approved expansion bolts may be used; when the cable or chain is attached to a bolt at a distance greater than one foot from the wall the bolt must be supported with a brace.

SIGNS WEIGHING LESS THAN 100 POUNDS

Minimum size allowed, galvanized cable..................	1/4	inch
Minimum size allowed, chain..........................	3-16	"
Angle less than 45 degrees, galvanized cable.............	5-16	"
Angle less than 45 degrees, chain........................	1/4	"

Signs weighing between 100 and 250 pounds must have one main support attached to a bolt through the wall, having a suitable washer plate; when the cable or chain is attached to a bolt at a distance greater than six inches from the wall, the bolt must be supported with a brace.

SIGNS WEIGHING BETWEEN 100 AND 250 POUNDS

Minimum size allowed, galvanized cable	3/8 inch
Minimum size allowed, chain	5-16 "
Angle less than 45 degrees, galvanized cable	1/2 "
Angle less than 45 degrees, chain	3/8 "

Signs weighing between 250 and 450 pounds must have two main supports attached to independent bolts through wall, having suitable washer plates, and each support must be anchored at the building wall by two other supports in the form of bolts or plugs.

SIGNS WEIGHING BETWEEN 250 AND 450 POUNDS—TWO SUPPORTS REQUIRED

Minimum size allowed, galvanized cable	9-16 inch
Minimum size allowed, chain	3/8 "
Angle less than 45 degrees, galvanized cable	5/8 "
Angle less than 45 degrees, chain	9-16 "

Plans in detail must be submitted and approved for signs weighing 450 pounds.

SIDE GUYS FOR ELECTRIC SIGNS

Signs having 20 square feet or less of side surface and guys spread at an angle

Greater than 45 degrees, galvanized cable	1/4 inch
Greater than 45 degrees, chain	3-16 "
Less than 45 degrees, galvanized cable	1/2 "
Less than 45 degrees, chain	3/8 "

Signs having more than 20 and less than 30 square feet of side surface, and guy spread at an angle

Greater than 45 degrees, galvanized cable	3/8 inch
Greater than 45 degrees, chain	1/4 "
Less than 45 degrees, galvanized cable	9-16 "
Less than 45 degrees, chain	5-16 "

Signs of over 30 square feet surface must have two side guys on each side of such sign, as may be required on the basis of the above. When signs are so located that the use of large cables or chains as above is required, the use of two smaller cables or chains in place of one will be allowed, the breaking strain of the two small cables or chains to be equal to that of the large ones indicated.

SIDE GUY SUPPORTS ON BUILDING

Side guys spread at angles greater than 45 degrees may be fastened with approved expansion bolts, in a solid brick or stone wall, or by a machine screw in an iron front; or by a lag bolt in solid woodwork. (Bolts or screws must not be fastened to window frame.)

Machine screws in iron front to be not less than one-half inch in diameter and must enter clear through the ironwork.

Lag bolts in solid wood to be not smaller than three-eighths of an inch in diameter and must enter woodwork at least three inches.

EXPANSION BOLTS

Expansion bolts must be at least three-eighths of an inch in diameter and must enter brick or stone walls, where permitted, at least two and one-half inches.

CONTRACT FOR SIGN LIGHTING
(FLAT RATE)

Agreement entered into this 10th day of November 1904 between the Standard Electric Co., hereinafter called the Company, and John Smith hereinafter called the Consumer, both of Jonesville, Illinois

This Company agrees to equip the premises of the Consumer at No. 148 Main St.: with a system of electric wiring for the use of one sign, and also to install and connect one sign of 88 - two candle-power incandescent lamps each, to burn upon the Company's constant potential circuit, said sign to be installed and to have thereon the lettering as herein described:

Size Of Panel to be		Style of Lettering to be
24" x 86"	D R U G S	Plain Block

The Consumer agrees to keep and use said sign for twenty-four months, beginning November 24th, 1904, and ending November 24th, 1906, and further agrees to pay the Company for said service at the prices hereunder written, subject to a discount of twenty five cents per ______ per sign, if payment is made to the Company on or before three days from date of bill rendered.

The signs will be turned on and off at hours specified by the Company and the Consumer agrees to burn the lamps on said sign , only during the hours specified, and will pay additional for any extra use thereof.

Said sign , with the necessary switches, wires and other appliances, are to be and remain the property of the Company, and the Consumer agrees to protect them from all injury, interference or tampering.

The Consumer also agrees that the Company's employees shall, at all reasonable hours, have free access to the premises for the purpose of examining, repairing or removing its property.

The Company agrees to use reasonable diligence in providing a regular and uninterrupted supply of electricity, but does not guarantee a continuous or uninterrupted service, and if said lamps fail to burn, or do not burn properly, or if for any reason the Company is unable to supply electricity, the Consumer agrees that the only liability of the Company shall be to abate the rent for the actual time of no service. It is understood, however, that if the current is furnished at the sign but if some of the lamps fail to burn on account of being burned out, there shall be no rebate, as the Consumer assumes the responsibility of getting renewals of burned out lamps from the Company's lamp room, which will be furnished without charge in exchange for the old lamps, and of installing them in the sign.

The Consumer hereby expressly authorizes and empowers the Company to remove the sign , switches and all its other property and to cut off the supply of electricity whenever any bills for said service are in arrears, or upon violation by the Consumer of any of the terms or conditions of this contract or of any other contract between the parties hereto; and in case of such removal the Consumer agrees to pay the Company as damages, not as a penalty, the full rate herein specified, without discount, for the full time said sign may have been furnished by the Company under this contract, less the sum total of all amounts that may have been paid by the Consumer for light under this contract, and in addition thereto pay the Company one hundred and forty dollars as liquidated damages, to cover the Company's expense in installing said sign on said premises.

HOURS OF SERVICE

1 Sign of 88 - 2 C. P. Lamps to burn from dark M. to 10 PM 7 days per week at Three and 8/100 dollars ($3.08) per week each.

In case of defective service, the Consumer agrees to immediately give notice of the fact to the Company's office. Collectors, solicitors, trimmers, emergency men and other line employees are not authorized to receive complaints, and the Company will not be held responsible unless complaints are made direct to the Company's office.

The Consumer agrees that he will not take down the sign or loosen any of its fastenings, or permit same to be done by anyone other than the representatives of the Company, and furthermore that nothing shall be attached to or hung from the sign .

The Consumer agrees to get the necessary permission from the proper authorities to hang the sign as provided in this contract and in event of failure so to do the Company will not be held responsible for failure to hang said sign.

The Consumer agrees not to permit anyone other than the authorized employees of the Company to install any lamps other than those furnished by the Company or any lamps larger than two candle-power in the sign and if he becomes aware of the fact that lamps larger than candle-power have been installed he agrees to immediately notify the Company.

It is understood and agreed that this contract shall be deemed to be renewed unless one of the parties hereto shall, on or before [illegible] days before the expiration of the time specified, give written notice to the other party of his desire to have the contract terminated.

This contract although signed is subject to the approval of the President of the Company and shall not be binding on the Company until endorsed with his approval.

It is finally agreed that all the terms and stipulations heretofore made or agreed to by the parties in relation to the use of said sign and the installation thereof are merged in this contract and that no previous representations or agreements made by the Company's officers or agents shall be binding upon the Company except as and to the extent contained herein.

Standard Electric Co.

By John Brown, Ag't.

Approved Nov. 10th, 1904 — John Smith *Consumer*

C. M. Dash, Pres. — *By* L. S.

FIG. 16

Sleeves must be provided for all cables and two cable clips must be provided for each cable end near the sleeve.

Turnbuckles of suitable size must be provided for all side guys and for one of the supporting cables where more than one is used.

Signs must not obstruct or be attached to any part of fire-escapes.

ELECTRIC SIGNS AND DISPLAYS OUTSIDE OF BUILDINGS—WIRES

Sec. A. Must have an approved insulated covering.

Sec. B. Must have ample carrying capacity.

Sec. C. Must, where entering wood or metal work, be protected with fireproof insulating tubes substantially secured to prevent slipping out of place.

Sec. D. Branch wires of like polarities may be bunched if placed in approved flexible tubing; provided that there are no splices or joints. Ends of tubing to be taped or compounded.

Sec. E. Must be supported every 12 inches where opposite polarities of circuits are nearer than one and one-half inches. Must be supported every two and one-half feet where opposite polarities of circuits are over one and one-half inches.

Sec. F. Must be supported on porcelain knobs or cleats which separate it at least one-half of an inch from the nearest surface.

Sec. G. Must be spliced or joined according to approved regulations and also be covered with an approved insulating paint.

Sec. H. Must have drip loops where entering weather frame.

Sec. I. Portable conductors connecting signs must be stranded according to regulations.

SOCKETS AND RECEPTACLES

Sec. J. Must be weatherproof, but where substantially protected from the weather may be of the open-clip pattern, so placed that clips shall have a clearance from wood or metal not less than one-quarter of an inch.

Sec. K. Clips must be substantially soldered to the wire and then thoroughly taped and painted with an approved insulating paint. (Supporting screws within sockets must be of such length and size and so placed that they will retain an air space under live clips as intended in design.)

Sec. L. Must be waterproof, where exposed to weather, having no outside contacts, and where pitched above a horizontal position must be protected at opening with an approved protecting ring or chamber to prevent rain or snow entering.

The President: It will not be possible to have the executive session now, and the meeting will stand adjourned until two o'clock.

FOURTH SESSION

The meeting was called to order at half after two o'clock by President Blood, who announced the first business of the afternoon to be the paper on *Profitable Co-operation,* by Mr. J. Robert Crouse.

MR. CROUSE: I want to make a slight correction to the remarks made by Mr. Almert this morning, in order that there may be no misconstruction of the spirit in which this co-operative programme has been conceived and carried out. I am sure he will allow me to make this correction.

This entire scheme of commercial co-operation, which I am to discuss with you briefly, is not based upon the proposition that the central-station manager is in any wise responsible for any conditions, prosperous or otherwise, more than other well-defined branches of the trade, and the subject is not treated from the standpoint of criticizing central-station operation.

Mr. Crouse read the following paper:

PROFITABLE COMMERCIAL CO-OPERATION

Introductory

Last year at your Denver convention, through the courtesy of Ex-President Davis and others of your association, I had the honor of calling to your attention a well-developed disposition on the part of the incandescent-lamp manufacturers to co-operate with central stations in increasing the use, and in consequence the sale, of incandescent lamps. This disposition was substantially evidenced by an appropriation of $10,000 voted by the forty-five or more competing incandescent-lamp manufacturers for the purpose. This action was taken from the conviction that there existed a community of interest between themselves and the distributing trade, central stations and others, on the basis of which co-operation could be employed to reach more effectively the market common in the last analysis to all, namely, the public.

In behalf of these manufacturers, I requested that a committee of three central-station managers should be appointed to look into the plans which had been formulated, and to assist in their further development. This your association was good enough to act upon favorably, and I am informed that you will hear from this committee with a report on the subject during your present meeting.

Results in the Rough

During the past year this subject has been followed up in what seemed to be the logical direction of its development, namely, a more extended community of interest among the different branches in the electrical trade, as was hinted at a year ago, with the following results:

First—These incandescent-lamp manufacturers, as an expression of their faith in the broader scheme which has been developed, made a further appropriation of one-fifth of one per cent on their sales for a period of three years, which, together with other appropriations, aggregates approximately $60,000 for the prosecution of the work.

Second—Thirty thousand dollars is being directly spent this present year in carrying out the initial plans as they have been drawn, and fully an equal amount will be spent through various bodies which are co-operating in the general movement.

Third—The Co-operative Electrical Development Association has been projected as the medium through which these more extended plans and policies could best be carried out.

Fourth—The plans of the new association have been presented to associations of electrical jobbers, electrical contractors, electrical salesmen, and various associations of electrical manufacturers, who have looked upon them with favor by appointing co-operating committees to assist in their development.

Fifth—The entire proposition was discussed in detail at a joint meeting of the electrical trades held in New York on March 23, 1906, attended by some sixty-five representative men from all lines of the industry.

The sense of the meeting was crystallized in the following resolution offered by Mr. Anson W. Burchard, assistant to the president of the General Electric Company, with second by your worthy president, Mr. W. H. Blood, Jr.

Resolved, That it is the sense of this meeting that the co-operative commercial campaign for the purpose of increasing the use of electric current by the public for light, heat and power, as both an end and a means to the increased demand for electrical apparatus and supplies, as presented and discussed, gives good promise of highly profitable returns to all concerned, and that the general plans for its prosecution through the Co-operative Electrical Development Association can be undertaken along equitable and practicable lines.

(Unanimously carried.)

A second resolution was offered by Mr. Anson W. Burchard with second by Mr. W. M. McFarland, acting vice-president of the Westinghouse Electric and Manufacturing Company, as follows:

Resolved, That a committee of eleven or more representatives of the electrical interests be appointed by the Chair for the purpose of considering the plans submitted for the organization of the Co-operative Electrical Development Association, and to complete and agree on a practical form of organization with a view to putting the same into operation.

Resolved, further, That this committee be authorized to confer on the subject with the co-operating committees already appointed, or other representatives which may be appointed from other well-defined lines of the trade, such as central stations, electrical jobbers, electrical contractors, electrical salesmen, trade papers, advertising agencies, and so forth, so that adequate provision may be made in the plans of organization for immediate moral co-operation as well as possible financial co-operation at a later date.

Resolved, further, That the plans of organization, when completed by this committee, be submitted to the representatives of the interests here present, so that the entire proposition may be passed upon by their respective bodies or companies.

When, in the opinion of this committee, a sufficient number of bodies and companies have agreed to co-operate in the work, it shall be authorized to perfect the organization and supervise its initiatory work.

(Unanimously carried.)

For the purpose of carrying the sense of the meeting, as expressed in the above resolutions, into practical effect the following representative committee was appointed by the chairman of the meeting, Mr. E. E. Jackson, Jr.:

W. M. McFarland, chairman, Westinghouse Electric and Manufacturing Company.
J. S. Anthony, General Electric Company.
Walter Cary, Sawyer-Man Electric Company.
A. D. Page, General Electric Company.
Gerard Swope, Western Electric Company.
F. S. Terry, National Electric Lamp Company.
W. C. Bryant, Bryant Electric Company.
F. T. Newberry, John A. Roebling's Sons Company.
A. T. Clark, American Circular Loom Company.
W. H. Blood, Jr., president National Electric Light Association.
Paul Spencer, United Gas Improvement Company.
John F. Gilchrist, Chicago Edison Company.
J. E. Montague, Buffalo & Niagara Falls Electric Light and Power Company.
F. Bissell, representing electrical jobbers.
James R. Strong, representing electrical contractors.

The Co-operative Electrical Development Association

It is, therefore, my desire to bring to your attention the Co-operative Electrical Development Association, and to discuss these initial plans and policies which it is proposed to work out

through it on the basis of unlimited commercial co-operation on the part of manufacturers, jobbers, contractors, salesmen, technical press, advertising agencies and central stations.

The proposition involves, in a word, the attempt to work out practicably and profitably a further extension of the pronounced tendencies of the times toward co-operation as evidenced by associations in all lines of business, and particularly in the electrical business by associations of nearly every well-defined line in the trade.

Objects of the New Association

The objects of this association, as stated in the *Suggested Plan of Organization,* are as follows:

First—The promotion of increased and more extended use of electric current by the public for light, heat and power against all competitors for like services, as an end in itself, and as a means to the increased demand for electrical apparatus and supplies and the co-operative planning and execution of various means and methods effective to this end.

Second—The establishment of co-operative relations, both moral and financial, among the different electrical interests, from the manufacturer to the consumer, to the end that each may contribute in some measure toward bringing about the above results desired in common by all.

Co-operation in Abstract

To reach a conclusion as to the merits of this proposition, the subject must be briefly discussed, first, from the standpoint of co-operation in the abstract as a commercial principle, and, second, co-operation as a practice—treating of the means to be employed.

Limits to Co-operation

Co-operation, or working together in business, is an object universally sought after, consciously or unconsciously, by every organization or corporation as a means to the increased efficiency in accomplishing whatever object is sought, through elimination of loss and friction in the working parts.

From this kind of co-operation, which is, of course, in evidence everywhere in greater or less degree, the principle has been

tried to the extent of socialistic and communistic co-operation in communities where it was thought that competition and commercial waste of all kinds would be entirely eliminated. Attempts to co-operate to such extreme degrees have in every case proved a failure, for the reason that they undertook to do away entirely with self-interest and private property as the necessary incentives to social and commercial activity. Experience, therefore, teaches that there are well-defined limits to the employment of this tremendous force.

Practical Limits to Commercial Co-operation

The above does not, however, lead to the conclusion that more extensive commercial co-operation than is at present employed in specific lines of business is impracticable, but it does emphatically suggest that the working basis for more extensive commercial co-operation must be measured in and limited to the terms in which a common object is clearly discoverable. In other words, if within the electrical industry the various branches and individual parts of it may have nine hundred and ninety-nine diverging or conflicting interests among themselves, it is quite conceivable and probable that the remaining one may represent a common interest or object in the attainment of which co-operatioh may be employed with great success and profit.

Basis of Common Interest and Co-operation

The ground on which the contention is based, that limited commercial co-operation is both feasible and fair for the manufacturing central station and other electrical interests, is the almost absolute dependence of the manufacturer making generating and distributing apparatus and supplies, for his market, upon the commercial activity of the manufacturer who produces the final utilities through which the market common to all—the public—is in the end electrically served. There are camparatively few in number as will be observed, in the field of light, the incandescent, the glower, the tube, and the arc lamp; in the field of heat, miscellaneous appliances for domestic and industrial purposes; and in the field of power, the motor—endless in detailed application. In money value, the output of these devices is only a fraction of the total volume of the manufactured product, yet they create the demand for all generating and distribut-

ing apparatus and supplies, and constitute the edge of the commercial wedge through which is opened up the market for all such apparatus and supplies—sockets, porcelain, wire, conduits, switches, meters, transformers, dynamos, engines, boilers, and so forth. Likewise, in turn there is the dependence of the manufacturers, jobbers and contractors in varying degrees upon the commercial activity of the central station and others in exploiting electric service to the public, and ultimately the dependence of us all, in turn, like links in a chain, upon this great, preoccupied, incredulous and indifferent public, with a purchasing power of $18,659,000,000 distributed among its 85,000,000 individual units.

The public has been induced by the aggressive commercialism of the automobile industry, a six years' infant in the industrial field, to spend in 1905 $35,000,000 for new machines and $70,000,000 on the operation of all cars in service, a total of $105,000,000, or within $25,000,000 of the income of all the central stations of the country, 40 per cent more than is spent on the sewing machine, a seventy-year-old industry, and nearly equal in amount to the purchase of pianos, an industry dating back to 1710.

The popularizing of electric service to this great final market is conceived to be a common object to us all, on the basis of which limited commercial co-operation is correctly founded.

What Commercial Co-operation Must Do to Justify Itself

Co-operation as extensive as is here proposed must make its successful appeal, primarily to good business, and secondarily to good fellowship, on the basis of the foregoing common object which it is desired to achieve, which, moreover, can not be accomplished in equal degree through any other means.

To prove its soundness as a permanent system, it must accomplish some of the following results:

First—Produce proportionately greater selling results if involving additional selling expense.

Second—Produce equal selling results with commensurate decrease in present selling expense.

Third—Render possible the prosecution of certain effective selling methods which on any other basis are likely never to be undertaken.

Fourth—Call into play voluntary constructive selling forces which can be influenced by co-operation more largely than by money.

The latter, while possibly slow to develop, will doubtless be found in the end to be the meat of profitable co-operation.

Fifth—Even without precedent, as appears to be the case in point, it should successfully stand comparison with the apparent commercial tendencies of the time.

In this latter connection, your attention is called to the following, which you will at once recognize as very briefly the order of business development: Individualism, Co-partnership, Corporation, Consolidation, Association.

This development has been in effect, from one step to another, a natural tendency toward co-operation and to the recognition of broader grounds of common interest, resulting on the one hand in tremendous increase in the efficiency of production, with lesser gains in the field of distribution or selling. Judged on this basis, the co-operation of an entire industry within the reasonable limits proposed and addressing itself to the field of generic selling and distribution, appears to be strictly in the line of commercial progress. To what extent it will stand the first four tests mentioned will be a matter for your judgment on the basis of what follows.

So much, then, for co-operation in the abstract, both general and electrical.

Electrical Industry Under-Advertised and Exploited

Right at the start let us get squared away on the general proposition that the electrical industry as a whole is seriously under-advertised and exploited commercially, if measured in the terms of other comparable industries or of its older competitors in the field of light, heat and power, particularly in the gas field.

This is believed to be no more true of the central station than of the other branches of the business, such as manufacturing, jobbing, contracting, publishing, or otherwise, and in any case is not advanced as in any sense a reflection upon the energy or the brains of the men who have developed it.

The time will not be taken to advance in detail the necessary proofs to substantiate this general statement further than the fundamental one, *viz.:* change, improvement and invention in

the means of generating, distributing and utilizing electric current have been so rapid that the engineering and operating ends of the business have naturally taken precedence over commercialism.

It will, therefore, in the spirit of co-operation be assumed that whatever conditions exist or have existed, prosperous or otherwise, are the complex products of the entire commercial chain of which we are all a part, and that we shall all be mutually interested in carefully considering any proposition that gives reasonable promise of accelerating the rate of growth.

As regards the commercial conditions in the central-station field, however, permit me to quote from the opening address of your president to the convention at Cincinnati in 1903:

> The central-station business is in an undeveloped state; its possibilities are problematic; there has been no uniform development of individual central stations. Some central stations have been developed to the point where they have wired up the equivalent of nearly two 16-cp lamps per inhabitant and have a revenue of from $3.00 to $4.00 per capita. Other central stations have but one 16-cp wired up to every ten inhabitants, and have a revenue of less than 50 cents per capita.

In this connection I desire to call your attention to the large chart No. 4 which indicates this point clearly, as well as other interesting facts.

Again your president said:

> We have not yet reached the commercial age, and I predict that within five years the members of our association will almost lose sight of engineering matters in their eagerness to increase their sales.
>
> Our earnings through economy of operation have well-defined limits, but the possibilities, of increasing our earnings by developing our market have a much wider range.
>
> I believe our business to-day might be considered of a retail nature compared with what it will be a few years hence.

Again he says:

> The interests of the central stations of the country and the interests of the manufacturers of apparatus I think are oftentimes identical.
>
> We want the assistance of all the manufacturing com-

panies and we can reap considerable benefit from their co-operation.

The Common Market and How Reached

This great common market, the public, is two-fold to the manufacturer, who must be considered, initially at least, as the fountain-head in the plans of co-operation as here advanced.

First—The central station, whose entire business and interest is furnishing electric service at a profit, and within the range of whose service is comprised a population of 33,411,090 or 43.96 per cent of the total population of the census of 1900.

Second—Isolated purchasers, to whom electric service, individually generated, is either partially essential or auxiliary—always a means to some other purpose.

The commercial energy reaching this common market spends itself as follows, in whole or in part: manufacturer, jobber, dealer, contractor, salesman, trade paper, advertising, central station. It will be observed that up to the central station it is competitive in the highest degree and under constant spur to commercial activity.

The central station, on the other hand, is conceded by economists to be in its very nature properly monopolistic, and subject therefore to no competition for identical service. In consequence, laying aside any other possible adverse considerations, such as a consolidation of gas, electric and other interests, it seems to lack this keen and constant commercial stimulus. It likewise seems to lack, by reason of isolation, either the ready opportunity or a very great incentive toward active aggressive co-operation, in spite of the fact that it presents a natural situation where extensive co-operation (as they are non-competitive among themselves) reasonably promises the greatest results from such work. The opportunity and the incentive are, therefore, presented to the manufacturing and distributing trade for initiating co-operative work with and for central stations, and of cultivating the entire possible outside market broadly in addition.

Co-operative Development of the Plans

In consideration and development of this entire proposition every branch of the industry has been fully consulted—central-station interests in particular—not only through your active co-

operating committee, but, as well, through President Blood and other progressive managers of central stations of all sizes. The plans are therefore advanced in the firm belief that they represent in some degree the best thought of a number of the most progressive men in the industry, which it has been my personal fortune and pleasure, through accident largely, to put into such orderly arrangement as may appear.

May I suggest that if they appear to have some merit the result be considered as the product of the co-operative spirit, and as an augury of the possibilities of the more general co-operation aimed at.

Co-operation with Advertising Agencies

For the open and aggressive work was secured the co-operation of several advertising agencies which are making a special study of effective advertising services to be used by the central stations in advertising electric service to their local publics, supplemental to and in conjunction with their solicitors. It will be their legitimate object to make a business of planning and selling effective advertising services to central stations, in connection with which a system is being developed for sending experts to assist in initiating and systematizing new business departments, covering both the field of personal solicitation and advertising.

Campaign of Commercial Literature

Through this medium a propaganda of twenty-six pieces of commercial literature is being issued to all central stations in co-operation with the new association. It will deal in the broadest way with the problem of business extension from the standpoint of good service solicitation and advertising. The subject will be dealt with, not on the basis of any theories on these topics, but will be founded on the practice of the most progressive central stations, judged on the basis of their annual *per capita* sales. It will further be distinctly instructive and suggestive in character, recognizing that conditions under which central stations operate vary, and that consequently set or arbitrary formulæ for business extension can not be successfully advanced.

This commercial literature will be briefly described under its three general divisions.

The Quarterly Magazine

Its leading feature will be a quarterly magazine, laid out under suitable headings, such as *New Business, and Why, Three-fold, the Means, Service, Advertising, Solicitation, Hints to Solicitors, What Others Are Doing, Timely Commercial Editorials, List of New Applications of Electric Current.* Under these headings all kinds of business-getting schemes, suggestions, and methods will be offered, representing the best commercial ingenuity and thought from central-station managers the field over.

The Newspaper Bulletin

The second section of the service will consist of an eight-page newspaper, designated by some such title as *Central-Station Advertiser,* issued quarterly. This will cover three points. For a year past, through clipping bureaus, the local newspaper advertising of central stations has been compiled into scrap-books. From this voluminous stock the most effective newspaper advertising for light, heat and power will be selected and reproduced in the newspaper bulletin, contrasted in turn with samples of inferior advertisements. In addition, well-illustrated advertisements will be shown, mortised for the name of the local company, which can be secured, in consequence of a syndicate service, at nominal rates. Central-station managers can, therefore, make free use of the first class of advertisements referred to, or secure a more elaborate and illustrated service both readily and reasonably.

The second part of this newspaper bulletin will be an editorial section in which central-station managers and others who have made local newspaper advertising pay will indicate the particular lines along which it has been accomplished. This will naturally treat of the best policies to be pursued in cultivating the good-will of local publishers and editors. It will discuss special phases of local newspaper advertising, such as the possibilities of co-operative local advertising on the part of local central stations, jobbers, contractors and telephone companies, through the means of which it may be possible to take, periodically at least, large, striking spaces, well edited and illustrated, covering the entire range of electric service.

The third part of this newspaper bulletin will contain popular news write-ups in reference to electrical improvements, de-

vices and service, which will be acceptable to the local papers for their reading columns or fillers, having, nevertheless, a considerable amount of advertising value.

It is planned to carry this feature further in the development of regular service of popular articles on electrical subjects, well illustrated with cuts, suitable for Sunday and industrial editions. Such cuts would be used but once in a place, and they could therefore be furnished repeatedly to one central station after another at a nominal cost for the temporary loan.

Much of this newspaper bulletin service, as will be observed, central-station managers can take advantage of with neither expense nor obligation, and the more elaborate services are within reach at a purely nominal expense compared with what would otherwise be the case.

Special Publications

The remaining sixteen separate issues of this commercial literature will treat of special topics along the same general lines. Booklets on the subject of successful schemes for securing the wiring of all new construction work will be issued periodically. These will present effective policies and methods pursued in places where notably good results are secured in this important work, dealing in addition with the policies established between the central station and the local authorities, contractors, electrical inspectors, architects, builders, real estate men, and so forth.

Without going into the further details of the individual issues of this commercial literature, the above general outlines will be sufficiently suggestive of their character.

In addition to the commercial literature above described, intended to be suggestive and instructive in character, other cooperating advertising agencies, equally well qualified, will be putting out campaigns and undertaking work along comparable lines. This part of the work is now well under way, and reaching all of the central stations in the country every two weeks or oftener, it is hoped, will prove of very great use in the more active and profitable extensions of electric service.

Co-operation of Electrical Trade Papers

Recognizing the influence of the electrical trade papers, upon which the industry depends largely for general information

regarding the progress of the art, their co-operation and assistance were sought along lines which it was believed would work out mutually advantageous. They fully agreed that there was an important work to be undertaken along the lines discussed, and in a spirit of co-operation opened up special departments in their columns devoted specifically under suitable captions to the topics of "More Business" and "New Business."

These departments, which are familiar to you, will therefore constitute a ready clearing-house for the presentation, discussion and criticism of new-business methods. In the course of time it may reasonably be expected that central-station managers will be glad to interchange their views more freely on commercial topics, and as this is increasingly accomplished particularly effective commercial policies and plans, developed in one place and used locally, can be brought to the direct attention of all the central stations, thereby multiplying their effectiveness by a fair percentage of all the central stations.

If the plans as discussed with the trade papers are carried out they certainly will have contributed very largely to the commercial departments of central stations in increasing the consumption of electric current, and, in consequence, the demand for apparatus and supplies. As evidence of what they have already done along these lines I call your attention to the fact that, inclusive of all the electrical trade papers, there have been published, during the first three months of 1906, 149 columns on purely commercial .and new-business-getting subjects as against thirteen and one-half columns for the same period of last year, an increase of 1003 per cent. Conferences have been held between representatives of the advertising agencies and the trade papers for the discussion of the entire plan, from which it appeared that both lines of work could be carried on harmoniously, each supplementing the other.

Co-operation of the Manufacturing and Distributing Trade

For the purpose of putting the entire industry in touch with the co-operative work under way and enlisting general co-operation, a mailing list of 4700 individuals, identified with the electrical business as manufacturers, jobbers, contractors, including their salesmen, as well as officers of electrical associations and societies of all sorts, was some months ago carefully pre-

pared. To this entire list statements regarding the scope and character of the work proposed have been issued. The commercial literature above described, which is sent to all central stations, is likewise being furnished to this supplemental list. There will be sent to them in addition periodical reports of progress whenever any results of especial interest may have been accomplished, or new policies outlined in the prosecution of which their active co-operation would be sought. There is every indication that a lively interest has already been aroused, and that the co-operation of all of these branches of trade, including the salesmen, is being secured, as evidenced by the receipt of hundreds of letters within the past few months, indicating both interest in and sympathy for the objects of the association.

When this tremendous selling force is made fully aware of the true spirit and character of the association, the personal factor strongest of all will be induced to give increased attention to new business and more business along these lines. Receiving simultaneously with central stations, and not at greater intervals than two weeks apart, everything issued by the association, or in connection with it, they will be put into position to discuss the subject both among themselves and with central stations from the same text or at such original angles as may occur to them.

In addition, through the co-operation of the Electrical Salesmen's Association the effort will be made to interest salesmen generally in the more careful observation of the commercial practices of the most progressive central stations visited, so that it may become increasingly the fashion and the mark of the best salesmanship to pass every good selling scheme along to other managers in the territory covered.

Likewise, through the co-operation of the Rejuvenated Sons of Jove, or through other means to set the fashion among electrical men generally of "boosting the game" (if you will permit a vulgar, expressive phrase) by putting in a good word for electric service, at least where it would conserve their own personal comfort and pleasure—by requesting electrical massage at the barber-shop (insisting upon it if there happen to be no facilities), calling attention to the usefulness of the electric cigar-lighter at cigar-stands, patronizing stores or shops where electric service is most freely installed, with complimentary mention in reference

to it; registering, in addition to the name, a diplomatic complaint to hotel proprietors where electric service is niggardly used in the office and lobby only.

If we all find ourselves at times recommending to friends our doctor, our baker, or candlestick-maker, is it not really worth while to cultivate the habit of boosting any kind of electrical service to possible consumers? Which is another way of putting the slogan of the association—"All Together, All the Time, for Everything Electrical."

The above is merely suggestive of innumerable ways in which salesmen and electrical men generally can effectively be instrumental in increasing the demand for electrical service, and confirming among some existing customers the wisdom of its selection. More important still, however, would be the reactive effect of stirring up interest in the question of business-getting problems of central stations and other buyers, and securing to the new association the interested personal co-operation of electrical men upon whose friendly counsel and criticism its success in a great degree depends.

These, then, may fairly be considered the constructive selling forces before referred to, which are not purchasable, and which it is firmly believed can be voluntarily called into effective play through co-operation.

Commercial Engineering Department

A commercial engineering department would be established and placed in charge of an expert central-station business-getter.

The activities of such a department would be along some of the following lines:

(*a*) Correspondence with central-station managers on any or all phases of the business-getting problem.

(*b*) Preparation and dissemination of commercial statistics of both a helpful and a stimulating nature. Among these would be included such comparative reports as is instanced by chart No. 4, dealing with detailed comparisons of methods and results of central stations in cities of similar size and conditions, on the assumption that the power of example is the greatest stimulus. Likewise, papers on particular phases of the business-extension proposition, as, for instance, the paper on the organization and conduct of a new-business department in cities of 50,000

population and under, for which the new association offered prizes aggregating $1000.

Tabulation, through co-operation with central stations and others, of the applications of electric current, which, in a small way, has already been undertaken, as you will see from the pamphlet accompanying this paper.

(*c*) Co-operation with the trade papers in furnishing any commercial information which they might be glad to use in their new-business department, and similar work with the advertising agencies.

(*d*) Co-operating closely with your special committees in the development of the work, as well as with co-operating committees already appointed by other branches of the business.

(*e*) Attendance at state electric light associations, which he should be able to address with mutual interest and profit.

(*f*) Upon request, the personal service of some one from this department should be available to central-station managers about to install new-business departments, or who were experiencing difficulties in the operation of those already established.

National Electrical Press Bureau

The plans contemplate the establishment at the proper time of a national electrical press bureau, through which write-ups could be systematically furnished to the daily papers of the country, as well as to trade papers in other lines of business to which electric service might be peculiarly adapted. This is at once a most subtle and powerful selling means, which can be only briefly referred to.

I call your attention to an illustrated article in the Sunday edition of the Cleveland *Plain Dealer* of March 4, 1906, consisting of a write-up on the *Electric Home,* which was at the same time sent to some 275 papers in different parts of the country as an experiment and demonstration of the possibilities of such work. Full reports have not as yet been received, but the article has already been used by a considerable number of the leading papers. This article, with its illustrations, it may be mentioned, occupied from two-thirds to three-quarters of an entire page.

On the other hand, recently, an article entitled *Blindness the Cost of Electricity* went the entire rounds of the press of

the country and was most distinctively to the detriment of electric service in the public mind. Every thrust of this kind against the best interests of the industry could, through a national press bureau, be promptly and effectively parried.

Lists of various lines of business are available which could be systematically reached through news write-ups in their respective trade journals, covering electrical improvement, applications or service, directly or indirectly, of interest in these special trades or professions. One of these lists, for instance, covers an enumeration of 205,936 people connected with the medical profession and its allied branches, such as hospitals, medical colleges, physicians and surgeons.

In Cleveland, recently, a baby, prematurely born, was successfully raised through the means of electric heating-pads, carefully adjusted about it, by which an absolutely uniform temperature was maintained. If the interesting details connected with this incident were attractively written up it would undoubtedly be possible to capitalize it in an advertising news write-up for journals and papers reaching these professions, if not, indeed, acceptable to the press at large. I but mention this as being indicative of the possibilities of capitalizing both great and small instances of this kind in the field of light, heat and power through automatically furnishing them to the trade papers or periodicals reaching the lines most probably interested.

(In *McClure's* for March, 1906, if interested, you will find in an article by Ray Stannard Baker a detailed description of the methods employed in this specialized field of work, including the records of some very astonishing results. Likewise, a copy of the address of Ivy L. Lee, a commercial publicist, before the association, March 23, in New York, will be gladly sent upon request.)

All the above activities are easily possible through co-operation, and on any other basis would not be worth while, as such articles must always be along generic rather than specific lines.

Magazines and Periodicals

The plans would contemplate further, at the proper time, the use of popular periodicals and magazines for advertising widely the advantages of electric service. To millions of people to whom electric service for light, heat and power signifies little,

I believe it is perfectly possible to very greatly and profitably assist central stations and others in driving home the idea that if there is a wheel to be turned, a dark place to be lighted, or heat to be applied for domestic or industrial purposes, the best means for its accomplishment is through the employment of electric current. Its unique and exclusive advantages for these purposes in the way of hygiene, cleanliness, flexibility, convenience, and so forth, could by this additional means be persistently driven home, suggesting always that information as to the detailed needs be sought from the local central station, jobbers and contractors. It will be observed that this, on the one hand, will cultivate very largely the field open to central stations and be supplementary to their activities; while, in addition, it will educate the entire existing field outside of central stations, including possible users of individually-generated current, to the advantages of electric service.

When it is considered that the magazines, periodicals and newspapers issued to the American people reach the enormous number of 8,168,148,749 separate pieces of literature annually and that on fifty magazines, monthly and weekly, $25,000,000 is spent for subscriptions and $25,000,000 is spent by advertisers—almost equal in amount to the sales of dynamos and motors for 1905—it must be conceded that we are considering a commercial force which is not to be lightly passed over.

In addition, it is quite possible that on the basis of such advertising in popular magazines and periodicals a very reasonable use of their columns could be secured in the way of write-ups of electrical devices, improvements, and so forth, the possibilities of which are clearly indicated in the *Review of Reviews* for February, 1906, article entitled *Promoting California by*

Public Organization

This general subject was exhaustively treated before the association at the joint conference before referred to by Mr. E. E. Calkins, and this address may be secured upon request by those who may be interested in it.

Through co-operation it is easily possible for the electrical industry to make effective use of this subtle and powerful selling machinery.

The Wiring of Old and New Construction Work

There are, additional to those in the electrical field (who are naturally interested directly in the wiring of new construction work), the following lists in other fields having more or less directly to do with the question of wiring buildings: 5206 architects, 2433 large building companies, 5786 general contractors, 42,516 real estate agents, 40,406 carpenters and builders; a total of 86,357.

Probably no single condition retards the growth of electric service to the extent of the properties of all sorts that have been erected within the last ten years without provision for electric wiring. There are undoubtedly thousands of buildings in which tenants would gladly use electric service, were it not for the fact that the properties are not equipped. It is a further well-recognized fact that it is extremely difficult to induce owners or the agents of properties to submit to having the interiors of the buildings torn up (as is the popular erroneous impression) for the installation of wiring.

In the development of the plans it would be contemplated to attempt a vigorous line of co-operation with the central stations, electrical contractors and others through the employment of a competent representative whose entire time would be taken up in co-operative work through every conceivable means to secure the wiring of old and new buildings. This would call for his attendance at the national and state conventions of all of the above classes of trade, or professions, and the presentation of papers which would forcibly bring to their attention the very great importance and advantage, not only of wiring properties, but of specifying in addition the necessary extra outlets for the use of diversified appliances in the field of light, heat and power.

The question of double circuits for light and heat or power would receive his particular attention, also all allied fields, such as the furniture manufacturers, who should be influenced to more largely put out at least high-grade furniture—tables, chairs, dressers, and so forth—with electric wiring accessories. He would make a particular point of bringing to the attention of all these special lines of trade, both through addresses at conventions and by propaganda in their trade journals, complete information in regard to improvements in electric service, new appliances, and so forth, endeavoring to supplement in this way the work of the

central stations and contractors, and aiming to bring about a situation where it may be as common to wire a house or other building as it is to install piping, or modern plumbing, or heating.

Such a representative would likewise make a point of attending national and state electric light associations where, by reason of wide observation and specialized attention to this important subject, he should be able to discuss the matter to the advantage of all concerned.

Other Lines of Co-operative Work

Special lines of co-operative work have been discussed with co-operating committees appointed by the associations of the electrical jobbers, electrical contractors, electrical salesmen, and so forth, which while preliminary in character are nevertheless susceptible of effective elaboration. The officers of the Rejuvenated Sons of Jove have become interested in the movement and a number of co-operative plans have been suggested which are entirely feasible, looking always to the accomplishment of the common objects of the associations. The general character of such co-operative work with these, as well as other organizations that have been approached, may well be surmised from the general tenor of the preceding, and will, therefore, not be treated in detail.

This, then, constitutes the general co-operative working plan for influencing directly and indirectly the great common market—the public—to the more extended use of electric service for light, heat and power, and in consequence increasing the demand for electrical apparatus and supplies. We believe that these plans are essentially correct if viewed from any angle and that they might have been just as consistently devised by your co-operating committee and advanced to the other branches in the trade, for the objects sought in the degree attempted are common, and susceptible, therefore, to co-operative treatment.

The means suggested are many and varied and attack the problem from numerous angles. As in competitive specific selling of a single corporation many lines of selling effort of various degrees of efficiency are undertaken in marketing a product, so in this scheme of co-operative generic selling every effective means will be eventually resorted to.

Possibilities of Results to Central Stations

The report of the Department of Commerce and Labor for 1902, covering 1900 figures, gives the income of central stations as $86,000,000, divided among the different services as follows:

Incandescent lighting	52.1
Arc lighting	29.7
Motors	16.4
Miscellaneous	1.8

The figures of 1905 are placed by the authorities at $135,000,000, representing an income of approximately $2.50 *per capita*. As is shown from the statistical chart, a limited number of central stations are getting an income of $5.00, $6.00 and $7.00 *per capita*. If an average income of $5.00 *per capita* be assumed to be a possibility, in that event the business could be doubled, and even in lesser degree seems to indicate tremendous opportunity for accelerated growth.

This would, therefore, seem to present to central-station interests a lively incentive toward increased attention to the business-extension problem and hearty co-operation with the other branches of the business in assisting in its solution.

The facts seem to indicate that in general the central stations which have these high *per capita* sales are aggressive along all modern business-extension lines, such as good service, advertising, display and solicitation, spending from two to three per cent of their gross income—one-third to advertising and two-thirds to solicitation. If this were the prevailing practice, central stations would be spending a minimum of $2,700,000 or a maximum of $4,050,000 along the lines that appear to result in the high *per capita* sales and profits.

Possibilities of Results to the Manufacturing and Distributing Trade

The appropriation of $287,000 by the manufacturers for this co-operative work, which was suggested in the Denver paper before referred to, would all be returned to the manufacturers in one year if it resulted in an increased demand for electrical apparatus and supplies of $1,913,330, estimating the profit on this amount of added business at 15 per cent. This increase would amount to only 1.34 per cent above the normal rate of growth, which it is believed it is not unreasonable to expect might be accomplished.

As further suggestive of the possibilities of returns materially in excess of the figures indicated above, consider the following concrete example:

Quantity of incandescent lamps sold in 1905	45,000,000
One per cent gain in growth over normal rate	450,000
Electrical-horse-power equivalent of 450,000 lamps (13 to the horse-power)	34,615
Cost per horse-power of all equipment necessary to operate	$125
Resulting in an increased demand for apparatus and supplies of	$4,326,875

The above illustration is taken by reason of the writer's familiarity with the incandescent-lamp business, but as the entire plan would be equally and impartially directed to stimulating the use of all kinds of current-consuming devices requiring the use of motors, electrical heating devices, arc lamps, glower lamps. tube lamps, and so forth, the possibilities of the successful conduct of this proposed association will be appreciated.

Conclusion

In conclusion, the general principle of limited commercial co-operation and generic selling as here advanced, we believe is essentially sound and charged with great commercial dynamics.

The plans as explained, while they do not pretend to be more than a reasonable beginning, we believe will produce selling results that can not be secured, dollar for dollar, in equal measure in any other way.

The manufacturers with whom all the means of electrical service originate are, on that account and by reason of financial strength and the conditions under which manufacturing is at present organized, the logical interests to initiate this movement. They have it in their power at almost a negligible tax upon their revenue to set the example of broad-guaged and effective co-operative work which will at the same time meet with the most cordial endorsement and co-operation at the hands of the entire distributing and purchasing trade, and a logical conclusion of which is that every well-defined interest in the industry will eventually participate financially in the work in reasonable proportion to the benefits derived.

Manufacturers and distributers are now spending millions of dollars for the sale of essentially similar electrical apparatus and supplies against each other, the new-business-building force of which it must be conceded is to a considerable degree dissipated in competition for trade which either already exists or which develops from a certain natural growth of the business.

The commercial scheme of co-operation herewith advanced seems to be a most promising experiment of spending a few thousands of dollars, 100 per cent of which will be directed, without competitive opposition, to the creation of new business, and it will have added to its effectiveness several hundred per cent in the good will and co-operation of the entire trade.

I am not willing to believe that this great electrical industry of which we are all so proud, typical of modern progress and charged with unmatched possibilities for the future in its mechanical and electrical development, will be either unwilling or unequal to the task of launching and carrying to a successful conclusion a commercial project of this kind for the acceleration of the rate of growth in the business.

This specifically means to the manufacturers who are asked to father the association a tax of $1.00 per $1000 of sales; $10 per $10,000 of sales; $100 per $100,000 of sales; $1,000 per $1,000,000 of sales; in other words, one-tenth of one per cent.

In times past your association has expressed the belief that co-operative relations with manufacturers would be advantageous to both. We hope you will recognize in this new association a vigorous attempt on the part of some of the manufacturers—we hope eventually all—to work with you along commercial lines in reaping these advantages.

To a very considerable degree its success will be measured in the terms of its practical assistance to central stations, and this assistance in turn will depend upon the degree in which effective co-operation is given to the new association by the central stations and other branches of the distributing trade.

If this programme meets with your endorsement, in behalf of the new association I respectfully request you to appoint for the coming fiscal year a co-operating committee of three representatives of the large, medium and smaller central stations to assist in the further development and prosecution of the plans.

THE PRESIDENT: Mr. Crouse is the father of this idea of profitable commercial co-operation. One of his children comes to us in the form of the committee that was appointed to co-operate with the manufacturers on advertising. The committee is composed of Mr. Paul Spencer, chairman; Mr. John F. Gilchrist and Mr. J. E. Montague. Mr. Spencer not being present, Mr. Gilchrist will read the report.

Mr. Gilchrist presented the following report:

REPORT OF COMMITTEE TO CO-OPERATE WITH MANUFACTURERS' ADVERTISING COMMITTEE

Mr. President and Members of the National Electric Light Association:

The interesting paper presented last June at the Denver convention by Mr. J. Robert Crouse had for its theme the possibilities of extending and increasing the use of electric current. This it was proposed to accomplish by concerted action on the part of manufacturers, dealers in electrical supplies, and all others interested in the increase of the electrical industry, in a scheme of systematic advertising for the purpose of educating the public in the applications of electric current and the advantages of its use.

The scheme as outlined was essentially a co-operative one, having for its object the general growth of the industry and therefore to the extent that it succeeded would be for the benefit of all interests, whether engaged in the production and sale of current or connected with the manufacture or handling of electrical apparatus, appliances or supplies. It was stated that definite action along these lines was about to be taken by some of the manufacturers to whom the idea had commended itself.

Of all the interests connected with the electrical industry the central station stands closest to the consumer and receives the first benefits of an increasing demand for current. This association, therefore, was asked to co-operate in the proposed work of the manufacturers' committee to the extent of appointing a committee to act in an advisory capacity and to assist by suggestions and criticisms in the development of the plan.

The members of your committee appointed for this purpose have individually or as a committee met with Mr. Crouse many times during the past year and by correspondence also have kept closely in touch with the work of his committee. The association is familiar in a general way with what has been done, and the paper presented at this convention by Mr. Crouse takes up the plan of the work and its proposed future development in

detail. It is, therefore, unnecessary for your committee to do more than to call attention briefly to the plan and to state what, in its opinion, are the benefits that are likely to be received by the central-station interests and to suggest the attitude which this association should take toward the work of the manufacturers' committee.

The work began in a proposal to expend a limited amount of money in calling the attention of central-station managers to some new business-getting ideas which have proved generally successful. In order that this work might be done in the most efficient manner and at the least expense, it was placed in the hands of an established advertising agency. With this branch of the work you have already been made familiar. The plan of the manufacturers' committee has grown so as to include the incorporation of an association known as the Co-operative Electrical Development Association, to be made up initially of a membership of manufacturers of electrical apparatus and supplies, and to have for its object the promotion of the increased and more extended use of electric current by the public. The directors and officers of this association are to be chosen by the representatives of the manufacturers who make up the membership, but there is provision for advisory directors from allied interests, such as the National Electric Light Association. The funds to carry on the work of the association will be contributed by the manufacturing companies who are members of the association. The association will have a permanent office and officers for the carrying on of the details of the work.

It appears to your committee that the work of this association promises to be of great benefit to the development of the commercial side of the electrical industry and therefore to the central-station interests. Attention should be called to the fact that its work will not be limited altogether to increasing the use of current by present or prospective central-station customers, but will cover the entire field of the application of electricity and will, therefore, be a benefit as well to the municipal plant that may be engaged in commercial business and to the isolated plant. Looking at the movement, however, in its broadest sense, it is apparent that whatever is done to popularize the use of the electric current will be of general benefit to the industry and therefore can not fail to help the central-station interests.

The Co-operative Electric Development Association will provide a permanent organization whose formation and whose management will be in the hands of representatives in every interest of the trade. Such an association can work along many helpful lines. This permanent organization should serve as a clearing house for the most successful new business-getting methods. The information collected along these lines can be made valuable to all the interests in the industry. It should, and undoubtedly will in time, have on its force men who can be considered as new business-getting engineers, whose service can be placed at the disposal of central-station managers at moderate charge to assist in the working out, in any situation, of the best methods of developing profitable business. It should be able to send a representative to the different conventions, not only to the national convention, but also to those of the different state organizations. In this way it can both keep in touch with the central-station interests and supply information in the form of reports and papers that, being based on a survey of the entire field, should be of great value to all.

The association will also be able to stimulate public interest in the use of electricity by judicious advertising. This work being undertaken by a general body can, we believe, be made helpful along lines which the specialized interests, either of manufacturers or of any particular station, can not now reach. For example, good work can be done by supplying reading matter to the newspapers and possibly by advertising in the popular monthly and weekly magazines, and in this way bringing before the public at large the manifold uses and advantages of the electric current. Such advertising can also be carried on in trade papers and journals that are more or less indirectly connected with the application of electricity, but which are now almost devoid of any reference to the subject. Such advertising work carried on in builders' and architects' journals, with reading articles describing the uses of electric current, should be of great value in sowing seed that will bring forth a bountiful harvest to the central stations. We all know how difficult it is to introduce electric lighting into houses that have not been properly wired when they were built, and can realize the importance of missionary work that will convince the architects and builders, and the public in general, that the wiring of the house at the time

of its construction is as important as the installation of heating and plumbing appliances. The Electrical Development Association will also co-operate with the distinctly electrical trade journals in the work of bringing into greater prominence the commercial side of the industry, so that their columns will be helpful not only to the central-station engineer, but to the commercial department as well. In such ways as outlined above and in many other ways, it would seem as if an association of this kind would work along fundamental lines to the benefit of all central stations, both large and small, and that it should be able to provide assistance and help to the commercial head of any central station who is anxious to benefit from the experience of others.

The financial obligations of the work as at present formulated rest upon the manufacturers. The central-station interests have been asked to bear no part of the expense. In this, of course, the manufacturers are working not altogether unselfishly, but with enlightened self-interest. As the work develops similar consideration of self-interest may lead the central stations to feel that it warrants financial support in proportion to the benefits derived. In the meantime your committee believes that the movement should receive the unqualified moral support of the members of the National Electric Light Association. The proposed Co-operative Association is an organization having for its object the common good, and its efforts should be received in the broad-minded spirit in which they are put forth.

It is the tendency to look upon any advertising scheme with considerable indifference and with a feeling that its results will benefit only the people who are backing it financially. The proposed work of this organization will, if it is successful, enable the manufacturers to sell more apparatus and appliances, but only in so far as it has first increased the demand for current. The sale of any current-consuming device benefits the manufacturer to the extent of the profit he may make from that particular sale, but its installation brings to the electric light station a source of revenue that may continue for years, the total profit to the electric light company from the sale of current which it consumes very largely exceeding the profit of the manufacturer on its original sale.

The success of the scheme, therefore, lies very largely in the hands of the central-station interests and the attitude which

they assume toward it will undoubtedly be the determining factor in influencing the manufacturers' committee to carry out in full the work which has been planned. As already stated, your committee feels that this attitude should be one of co-operation and support.

In conclusion your committee recommends that a committee of the National Electric Light Association be again appointed in the coming year to assist the Co-operative Electrical Development Association in the work which it has planned to do.

Respectfully submitted,

Committee, PAUL SPENCER, Chairman,
JOHN F. GILCHRIST,
J. E. MONTAGUE.

May 9, 1906.

DISCUSSION

THE PRESIDENT: These two papers are open for discussion.

MR. A. L. SELIG (Los Angeles, Cal.): I move the adoption of the recommendation of the committee as contained in the conclusion, for the appointment of a committee to co-operate this year.

(The motion was carried.)

MR. CONVERSE D. MARSH (New York City): Mr. Crouse has presented in his chart, which I think most of us have seen, a very comprehensive method of advertising. Advertising agents know that if there is a united effort along all the possible lines of publicity much larger results per dollar expended can be accomplished than if only a few lines are taken up at once. Advertising movements that are national in character have much greater force than when they are only presented locally. When they are presented both nationally and locally they have the greatest force that the advertising agent knows how to effect.

This subject of advertising is comparatively a new one with central stations. I know when I first took it up, in 1903, with Mr. Edgar, of Boston, Mr. Insull, of Chicago, and Mr. Doherty, of Denver, the advertising that had been done by central stations in the country, and the new business obtained by it, was a negligible quantity. Since that start, however, there seems to have been aroused a general interest among central stations in this

matter of advertising. Now, if the central stations themselves are aroused, the next thing is to arouse the people that the central stations want to get business from, and that is a much more difficult matter than stirring up an intelligent body like a central-station men's association. Electricity is their business, and they are comparatively easy to interest concerning it. Electricity is not the business of the people from whom you want to get money, and it is therefore difficult to awaken them properly as to the value to them of your business. They have their own interests to think about primarily. I have seen many plans for obtaining business through publicity, but never saw a plan so comprehensive as the one Mr. Crouse has presented. It requires something out of the routine, something remarkable, if you are going to really stir up the people and double the earnings of a central station. Mr. Crouse, in his plan, has moved all along the line, taking into consideration the big things and the little things, and does not seem to have neglected much of anything. As an advertising man, I should say unqualifiedly that such a plan as he has suggested, if carried out thoroughly, with the co-operation between the manufacturers and the central stations, will be of enormous value, not only to the manufacturing interests, but to a considerably greater degree to central stations, for the manufacturer makes only one profit on his apparatus when sold, whereas the central station can reap an annual profit on such apparatus. A generator in use earns in a period of ten years many times its original cost.

Mr. John F. Gilchrist: I should like to emphasize further one clause in the report of the committee, which I think will bear emphasis, and that is that I believe that the best results from this proposed campaign of co-operation will reach the central-station people. There is undoubtedly a feeling on the part of some of us—I know I have come in contact with it and I presume other gentlemen have—an inclination to shrug our shoulders and say it is a scheme on the part of the manufacturers to sell their goods. It is, but it is a good clean one. Mr. Crouse has put in a year of the most remarkable energy, absolutely unpaid, on work along these lines, and while the manufacturers will undoubtedly profit from the sale of their goods, for every dollar they make the central stations will ultimately make $100. I think it would be fitting for this association to adopt a resolution of support to

Mr. Crouse's efforts, to help him get the manufacturers, the central stations and everybody in line.

I have another suggestion that I think would be interesting, and that is if we could have a word from some of the gentlemen representing properties in the southern states as to the effect of the magazine and newspaper advertising that has been done by commercial interests in lines other than electrical in the South, with the idea of benefiting them. I know that a great deal of it has been done—it has come under my attention. I think some of the gentlemen from New Orleans, Mr. Scherck, who represents some southern properties, and Mr. Brine, of Atlanta, could possibly give us some very interesting information as to what has been accomplished by that line of advertising in other industries.

Secretary Eglin announced an invitation from the Public Service Corporation of New Jersey to the delegates to visit its generating stations and substations.

The following telegram from Past-President Henry L. Doherty was read by the secretary:

"Sorry I am unable to attend the convention, but hope it will be the most profitable in the association's history."

The President: We will now take up the report of the committee on protection from lightning during 1905. Mr. Dow, the chairman of the committee, is not present, and the report will be read by Mr. Robert S. Stewart, of Detroit.

Mr. Stewart presented the report, as follows:

REPORT ON PROTECTION FROM LIGHTNING DURING 1905

The effects of lightning and static disturbances depend so much on local conditions and are felt at such rare intervals that it is not possible to formulate any general principles from the study of the experiences of a single lighting and power system. If, however, we tabulate the experiences of a large number of stations, located in all sections of the United States, these statistics should be very helpful in deciding on what methods of protection should be adopted in any particular case. In order to obtain such statistics your committee sent to each of the companies in the National Electric Light Association a circular letter asking for information in regard to lightning troubles during 1905.

The replies were classed under two general heads: Stations operating under 10,000 volts and stations having transmission lines of 10,000 volts or over. This division is natural, for very few, except the stations operating at very high voltage, have long-transmission lines, and the methods of protecting transmission lines are different from those used in distribution lines.

Each one of these two classes was divided into three, as follows:

A. Companies suffering no damage.

B. Companies whose losses were confined to lightning arresters and meters.

C. Companies suffering more serious losses. All who had lost transformers or other expensive apparatus were included under this head.

The following table gives the results of our inquiry:

STATISTICS FROM REPORTS ON LIGHTNING TROUBLES DURING 1905

	Under 10,000 Volts			Over 10,000 Volts			
	A	B	C	A	B	C	Total
Total companies reporting....	40	19	25	15	3	11	113
Total kw capacity of stations.	33,230	70,200	25,775	50,825	4985	84,680	269,695
Average kw capacity per company	830	3690	1030	3390	1660	7700	2380
Stations under 200-kw........	12	2	7	0	0	0	21
" 200 to 490-kw........	9	3	3	4	0	1	20
" 500 to 990-kw........	7	3	9	2	1	1	23

	Under 10,000 Volts A	B	C	Over 10,000 Volts A	B	C	Total
Stations 1000 to 1490-kw	4	2	0	2	0	1	9
" 1500 to 1990-kw	4	1	1	0	0	1	7
" 2000 to 2990-kw	2	3	2	0	2	0	9
" 3000 to 4990-kw	1	2	2	4	0	2	11
" 5000-kw and over	1	3	1	3	0	5	13
Distribution voltage							
110 to 250 volts	9	2	0	0	0	0	11
500 to 700 volts	8	6	10	4	3	7	38
1000 to 1200 volts	9	1	6	1	0	1	18
2000 to 2500 volts	21	16	19	14	3	9	82
4000 to 4600 volts	1	0	0	0	0	0	1
Transmission voltage							
3500 to 4600 volts	0	2	2	..	..	..	4
5500 volts	1	0	0	..	..	..	1
6600 volts	3	3	3	..	..	..	9
10,000 to 13,000 volts	..	..	..	9	3	5	17
20,000 to 24,000 volts	..	..	..	4	0	3	7
30,000 to 36,000 volts	..	..	..	2	0	1	3
40,000 to 45,000 volts	..	..	..	0	0	1	1
55,000 volts	..	..	..	0	0	1	1
Length of transmission lines—miles	28	117	35	438	64	614	1296
Under 60 cycles	0	2	0	1	0	2	5
60 cycles	25	15	16	14	3	9	82
125 to 140 cycles	7	0	9	0	0	0	16
Single-phase	11	2	7	0	0	0	20
Two-phase	9	4	7	3	1	0	24
Three-phase	12	11	11	12	2	11	59
Direct-current service only	8	2	0	0	0	0	10
Companies using G. E. arresters	22	16	17	10	1	11	77
Companies using Westinghouse arresters	14	7	17	6	2	5	51
Companies using Stanley arresters	4	4	4	0	0	0	12
Companies using Garton-Daniels arresters	3	4	5	0	1	0	13
Companies using miscellaneous arresters	2	1	0	0	0	0	3
Companies using choke coils	8	7	10	9	2	9	45
Companies using no choke coils	14	8	10	4	0	2	38
Companies using overhead ground wires	1	3	0	3	1	2	10
Companies using no overhead ground wires	35	14	24	11	1	9	94
Apparatus injured during 1905							
Lightning arresters	0	45	38	0	4	20	107
Transformers	0	0	70	0	0	26	96
Meters	0	28	38	0	0	0	66
Armatures	0	0	5	0	0	3	8
Oil switches	0	0	2	0	0	4	6
Shut-downs due to too violent discharges or to arc holding on in arresters? Yes	1	11	6	3	1	7	29
No	39	8	18	12	2	4	83
Number of times	3	21	20	8	4	30	86
Were there damages therefrom? Yes	0	13	13	1	2	7	36
No	40	7	11	14	1	4	77
Were apparatus or lines burned out or grounded due to failure of arresters to discharge? Yes	2	7	12	2	3	9	35
No	38	9	10	13	0	2	72
Number of times	4	13	28	2	6	37	90
Were there damages therefrom? Yes	0	6	18	2	2	10	38
No	39	9	7	13	1	1	70
Shut-downs due to discharges between line wires.....Yes	1	0	2	2	0	2	7
No	39	15	21	14	3	7	99
Number of times	1	0	9	2	0	2	14
Have poles been split or insulators been broken by lightning discharges? Yes	2	4	7	6	2	5	26
No	31	11	15	7	1	6	71

	Under 10,000 Volts A	B	C	Over 10,000 Volts A	B	C	Total
Number of poles split........	3	13	19	30	4	25	94
Number of insulators broken.	..	..	4	..	..	18	22
Companies reporting that damages are most frequently caused by severe storms...	8	12	20	6	3	8	57
Companies reporting that damages are most frequently caused by mild storms and static charges.............	1	1	1	1	1	1	6
Are lines seriously affected at a distance from the centre of a storm?............Yes	0	3	1	1	0	2	7
No	15	13	13	11	3	8	63
Shut-downs due to damages caused by sudden changes of load or short-circuits...Yes	9	5	13	4	0	5	36
No	18	11	10	9	3	5	56
Number of times	19	19	37	14	0	89	178
Were the damages serious? Yes	0	0	4	0	0	1	5
No	27	15	16	13	3	8	82
Is your lightning protection satisfactory? ....Yes	20	8	6	7	1	1	43
No	9	10	16	6	2	9	52
Companies advising the use of more arresters..........	7	2	10	3	1	1	24

In analyzing these results we would call special attention to the following points:

Freedom from Trouble—Two-thirds of the companies have been practically free from trouble. This proportion holds in the high-tension as well as the low-tension plants. In the plants of large kilowatt capacity this is apparently reversed, but, when you consider that one transformer was lost for every 1850 kilowatts station capacity under 10,000 volts and one for every 5400 kilowatts capacity over 10,000 volts, it is surprising that more of the large plants are not in the troubled class "C."

The money value of property destroyed by lightning is extremely small compared with the value of the plants, for, even when transformers are burned out they can be repaired at a moderate expense. The principal loss is due to interruption of service.

The freedom from trouble is due largely to the increased use of lightning arresters and largely to the high grade of insulation in modern transformers and generators. Every year, as old transformers are replaced by newer types and as defective lightning arresters are replaced by more efficient types properly located in the system, the troubles should diminish.

Type of the Average Station—The standard station at the present time runs at 2300 volts, 60 cycles, three-phase. There is a large number of two-phase stations operating below 10,000

volts, but above 10,000 volts practically all plants are three-phase. The average size of stations below 10,000 volts is 1540 kilowatts and of stations of 10,000 volts and over is 4840 kilowatts.

Arresters Injured—There has been quite a little trouble with burned-out graphite resistances in lightning arresters. This resistance is a very variable quantity, being greatly affected by electric discharges. Carborundum and other mixtures are used in the latest types, and resistances of these materials seem to be constant and do not fly to pieces as the graphite rods do. The wire resistances in the Westinghouse low-equivalent arresters have also burned out in several cases. Objection is made to the wire resistance that the path to earth is very far from straight and that the choking effect of this circuitous path must be great. It is to be hoped that the manufacturers realize that the resistances are the weak spots in their arresters and that they will be able to furnish resistances which are free from the troubles of the past.

Transformers Burned Out—These have been usually small, old, air-cooled type or switchboard series or shunt transformers. Very often transformer fuses are blown or lightning jumps from the transformer lead to the case without injuring the transformer.

Meters Burned Out—Wattmeters are frequently burned out. The damages are slight and there is usually no interruption to the service, but the company loses quite a little while the meter is not registering.

Armatures Injured—There has been little trouble with the main generators. In one high-tension plant the two generators, which are well protected by arresters, have burned out repeatedly during mild storms. All burn-outs have been short-circuited coils and none have been due to discharges to earth. These generators are 200-kw, 6600-volt, 3-phase, Y-wound machines, and both the inductance and the length of wire in the armature are consequently very great. It is very possible that the length of the static wave in the armature is reduced so much by the inductance that it is sometimes comparable in length with that of the wire in the armature. With such short waves, the difference of potential between the lightning arrester taps will be small and the arresters will not protect the generators. Our recommendation was to connect lower-voltage arresters across portions of the armature winding, of course leaving no part of

the winding unprotected by an arrester. A discharge would jump across one arrester after the other in succession (not simultaneously), and the maximum potential strain would be that necessary to break down each low-voltage arrester.

Suppose, for example, that a short electric wave enters the generator and that its wave length in the armature is just equal to the length of wire between two terminals. The potential difference between the two terminals, due to the discharge, would be zero. If, however, the potential difference across one armature coil were measured it might be very large. In this case an arrester placed across the terminals would be of no use, but several connected across the several sections of the armature would be effective.

Very few stations experience similar trouble, for their high-voltage generators are larger, the length of wire in the armature is less and the inductance is smaller. The electric waves are therefore much longer compared with the length of wire in the armature circuit. It should be noted, however, that trouble in high-voltage transformers may often be due to this cause. In several cases transformers protected by choke coils and arresters have had the leads punctured on the transformer side of the choke coils. The question is "what was the good of the choke coils if they did not prevent this." Possibly the choke coils added just enough inductance and length to the transformer circuit to reduce the potential difference across the arresters for that particular discharge. This trouble was guarded against when choke coils were first used by connecting arresters to both the transformer side and line side of the coils.

The Use of Choke Coils—These are usually installed in high-tension plants, but in plants under 10,000 volts choke coils are not very common. No argument, for or against their use, can be deduced from the replies received, for the main generating stations have had few burn-outs. Many series transformers on station switchboards have been burned out, both in stations protected by choke coils and in those unprotected. A considerable part of the discharge must have passed the choke coils to burn out this apparatus. Experiments have shown that choke coils reduce the strain on the ends of the windings of generators or transformers, and they should therefore prevent this apparatus from receiving as high a potential strain as that required to break down the arresters.

The Use of Overhead Ground Wires—Overhead ground wires are rarely used. On distribution lines they are a menace to the linemen and have been taken down, after trial, by several companies. Barbed wire is especially troublesome. The benefit derived from overhead ground wires on distribution lines is doubtful. On transmission lines they are of undoubted service. The few companies that use them report that they are well satisfied, and some are even enthusiastic. It is still a disputed question as to whether they are worth the cost. There is danger of trouble from breaking of these ground wires unless they are very heavily galvanized iron or heavy copper wires, and either of these would add considerable to the cost of a line.

The Use of Lightning Arresters—Most companies have learned from "before and after" experience that lightning arresters are absolutely necessary. As to the location of these, many feel that they have not enough on the lines. One very good way of telling where new arresters are required is to keep a special map of the distribution system and mark on this the location of any burn-outs. Lightning may never strike twice in the same place, but it often makes itself manifest in the same part of a distribution system. A system of different marks can easily be arranged to show what kind of apparatus was injured, how it was protected by arresters, how severe the storm, *et cætera.* Much more can be learned from such a map than from the records usually kept.

It should be remembered that, except on railway lines, arresters should be located near apparatus to be protected or on junction poles. It is very good to have a general rule as to the proper number of arresters per mile, but the rule should be flexible enough to permit of locating arresters near transformers. If there is a long distance between transformers, the capacity of this line helps very materially in keeping down excessive potential strains and therefore needs no arresters.

On transmission lines arresters should not be scattered along the line, for an arrester is a weak spot on the line and should be placed where it can be inspected from time to time. Apparatus connected to the line is what needs protection rather than the line itself.

Failures of Arresters—The chief cause of trouble seems to be due to failure of arresters to discharge, though there was

nearly as much trouble due to too violent discharges through arresters. Apparently there is little trouble in the average station from discharges between line wires. Many such discharges, however, may not have been recognized as such. Static discharges are assumed as going to earth unless there is positive proof to the contrary.

Shut-Downs Due to Sudden Changes of Load and Short-Circuits, and the Damages Resulting Therefrom—Short-circuits and sudden changes of load do not seem to have set up high-frequency currents that damaged insulation very much. In one plant high-tension cables were sometimes punctured from this cause. In another case a 20-kw transformer was burned out and probably this was the cause rather than the result of the short-circuit. No other short-circuits reported were followed by damages that could have been brought about by high-frequency currents. Experimental tests and several actual examples show how destructive high-frequency currents set up by short-circuits and sudden changes of load may occasionally be, but in the average plant the conditions do not seem to be just right for setting up these dangerous oscillations.

Protection of Poles and Insulators—One argument for overhead ground wires is that the poles and insulators are protected thereby. Only 25 per cent of the companies replying to this question have had poles struck, and on the poles struck few insulators were broken. One pole was struck for every 2860-kw capacity of station. One pole was struck for every 19 miles of high-tension transmission line and one insulator was broken for every 62 miles. Interruptions to service due to broken insulators are very rare and are confined to special localities. Every company should be able to tell from its past history whether or not special precautions should be taken to guard against broken insulators and poles.

Are the Damages to Apparatus Caused Most Frequently by Severe Storms, by Mild Storms or by Static Charges on the Wires?—Practically all who have replied to this question have most trouble from severe storms. Four have had the same trouble from static as from severe storms. Arresters which discharge freely or, in other words, which do not have too much resistance throttling the discharge, should therefore be most useful. The long air gap generally required for such an arrester

prevents it from handling the occasional trouble from static charges and mild storms. An arrester with a long air gap, part of which is shunted by a high resistance, is equally effective in both severe and mild storms.

Are Lines Seriously Affected at a Long Distance from the Centre of a Storm?—Nearly all answer this question by "no." Some, however, cite special cases where apparatus has been injured several miles from the storm centre. Waves of low frequency may travel long distances on the line until they find a weak spot or are reflected back at the end of the line with increased potential at this point. The ends of long lines should therefore be provided with arresters. Those with short gaps and resistances, or with both series and shunted gaps, are most suitable at the ends of lines.

Are You Satisfied that Your Apparatus Is as Fully Protected as You Would Wish?—In reply to this question most of those who had little trouble were satisfied and most of those who had had trouble felt that there was much room for improvement. The majority thought that this improvement should consist in the installation of more arresters of similar type. Quite a few who "had never had any trouble" were not satisfied with their protective apparatus. They probably felt that they were lucky and that this luck might change if they gave too much credit to their arresters. Several objected to the large number of angles and bends which the discharge to earth has to make in some of the standard makes of arresters, and many thought that the resistances used could be much improved. Only two or three made severe criticisms.

Experience of the Different Sections of the United States—The South Atlantic, Central and Northwestern states appear to have had the most trouble. The Rocky Mountain district reported no trouble except in two large plants in Utah and Colorado. The New England, North Atlantic, Pacific and Southwestern states had about the same amount of trouble as the average of the entire United States.

As over one-third of all the reports came from New England, New York and Pennsylvania, the conclusions concerning the trouble in most of the United States are based on meagre testimony. Except in New Mexico, Arizona, South Dakota and Nevada, the reports are very well scattered over the United States.

The portions of the United States in which lightning was most destructive were as follows: Southeastern Minnesota, Iowa, Missouri, Illinois, Eastern Ohio, North Carolina and Northern Georgia. It may be that the companies reporting from these sections were more unlucky than the others.

Conclusions—In analyzing the statistics it should be remembered that complete records of lightning troubles are seldom kept and many of the figures are very approximate estimates. Any conclusions that may be drawn should therefore be qualitative rather than quantitative.

Respectfully submitted,

Committee, ALEX DOW, Chairman,
C. A. HONNOLD,
ROBERT S. STEWART.

DISCUSSION

THE PRESIDENT: In considering the question of lightning protection, I have asked to be present and to take part in the discussion a gentleman who has given the matter a great deal of study. I take pleasure in introducing Mr. N. J. Neall, who while with the Westinghouse Company achieved distinction for his work in this field and who has become a recognized authority on the subject of lightning protection.

MR. N. J. NEALL (Boston): In the last few years, the extensions of transmission lines and the amount of apparatus employed have called for a different attitude on the question of lightning-protective apparatus, and the excellent report just presented undoubtedly shows the changed feeling that the association as a whole entertains on this subject. I think, however, that it is merely a beginning, and is not conclusive (although this is not detrimental to the value of the report in the present instance). My statement is based simply on the obvious fact that one can not tell how protective apparatus behaves by one year's performance, and I should therefore recommend that this investigation be continued for at least three or four years more. Moreover, a very good thing to do in this connection would be to have plants selected for their known vulnerability to discharges, and have them even more carefully watched than in this case.

I am inclined to believe that the companies that have reported, 113, do not represent all such companies as are interested in this subject, and it is probably but a small percentage of those concerned.

I have not any very general remarks to make on this occasion, but a number of thoughts are suggested by the report itself, to which I refer as follows:

Certain important items are omitted from the classification, which could have been added to it; for example, the number of lightning storms per system. There is no way to tell whether a system had one destructive storm or had fifteen other storms through which it passed without any disturbance.

There should also be the percentage of total arresters installed that were lost by reason of failure.

Another important point omitted was the lightning arresters per point of power delivered; that is to say, if you have a transmission line with a power-house and a substation, the importance of the protective apparatus is much greater than when you have a line distributing power over large territory and have something like a thousand transformers.

Another point of great importance to the manufacturing companies is the items dealing with the customers' use of various protective devices. By going over the list I find that of the companies suffering failure either of the protective apparatus or of the apparatus thereby protected, 59 per cent approximately of those using General Electric designs were affected, 61 per cent of those using Westinghouse, sixty-six and two-thirds per cent of those using Stanley, 77 per cent of those using Garton-Daniels, and thirty-three and one-third per cent of those using miscellaneous types. These percentages, however, are not of equal weight, because seventy-seven companies, total, for example, used General Electric arresters against three using miscellaneous. I am very skeptical as to the reliability of these percentages. It may be indicative of the relative merits of the protective devices that we find this curious relation, but I do not think this one test proves that these devices can be guaranteed for only 40 per cent of the storms. Another curious point is the fact that those who use choke-coils and those who do not use choke-coils make up only 83, whereas the number of companies reporting is 113. If the companies

were asked to say whether they do or do not use the choke-coil, it would seem that the number of answers should be 113.

Going further into the body of the report, I find some statements that are almost epigrammatic. For instance, it says: "The principal loss is due to interruption of service." It is not to-day so much a question of loss of protective apparatus or of apparatus thereby protected, as of loss of prestige to the operating company in having its service fail at some critical juncture. The public has become more familiar with these things and a failure reflects much more than it used to do on the operating and manufacturing companies involved.

Another point is the relative discharge ability of the apparatus protected and the apparatus protecting. This means that the relative freedom with which a static discharge can be made to pass through a given path is measured for convenience by the opening of a spark-gap placed in multiple with the apparatus under test, from which it can be demonstrated that by reason of aged insulation it is often easier to pass a discharge to earth through the transformer or the generator than through the protective apparatus itself.

There seems to be an implication in the report that manufacturing companies have endeavored to force the use of certain resistances for lightning-arrester service when there was obvious need of betterment. It is safe to say that in this respect any manufacturing company would improve its resistance if it could, but the very criticisms made touch to the quick the limitations of the materials. A resistance for use in lightning-protective apparatus should give a free static discharge path and yet be able to reduce the short-circuit current flow to the desired degree. Any resistance finally used must make the best compromise possible of these qualities. Let us examine certain well-known forms from this standpoint.

First—Wire Resistance: Any desired ohmic value can easily be secured from this material; but for very high-frequency discharges the wire introduces a skin resistance that gives it a high equivalent spark-gap. Very fortunately, this defect can be overcome by bending the wire back on itself in a loop, thereby greatly reducing the skin effect. In certain commercial forms this idea of looping, or, more properly, neutralizing the static fields, has been carried out to a high degree. Although to the ordinary observer this apparently introduces a circuitous route to ground,

yet it is a fact that it is easier for the discharge to pass over this path than if it were perfectly straight. This has been corroborated many times. After such a resistance has been assembled, however, there still remains a certain amount of skin effect that can not be easily overcome. The final result is therefore a compromise.

Second—Carbon Pencil: This form of resistance probably represents the most compact arrangement for great range in ohmic value. It was originally made of finely-divided carbon particles and a binder, but it was discovered that the passage of static discharges enormously increased the ohmic resistance, and lately carborundum has been substituted for the carbon to overcome this. The serious defect of such a form of resistance is its low current-carrying capacity and its high equivalent spark-gap, which can not be improved materially by the juxtaposition of any two pencils. Commercially, the carbon pencil has many attractive characteristics, such as low cost, simplicity of construction, ease of installation, and so forth, and it has been used quite extensively. There are other materials suitable for this service, each of which has some radical objection that limits its application. A new idea in such matters is to have a resistance so high in ohmic value that short-circuit currents can not be carried, but so arranged as to permit the ready discharge of static disturbances. One form of this is the Westinghouse M. P. discharge block. It is obvious that the application of resistances to lightning-protective apparatus has been carried out very well when one considers the limitations of the materials that can be used therefor.

The paragraph dealing with injured armatures seems to me out of place in this report. It is hard to believe that the members of this association care particularly to theorize as to whether it is a long wave or a short wave, and it must be little satisfaction to a station manager to know that his generator was destroyed in this way. It has often been said that engineering criticism should be of a constructive character, not destructive, which seems to be the nature of this particular section. This need not be the case, however, as the following considerations will show. The fact that low-capacity and high-voltage generators are subject to this behavior is a matter of concern to the manufacturing company dealing in protective apparatus, but it need not hold

a man back from using that size of generator if it be expedient. As a protection he can use step-up transformers, with ratio one to one; use better insulation between turns; or use special protection around the generator, in the form suggested, if it is a stationary armature. If it is a revolving armature this can not be done.

I find no mention made of the methods of grounding in this paper, and that seems to me a matter that should have been looked into. The quality of the ground and the general conditions of the plant have a great deal to do with the performance of protective apparatus.

This paper has tried to cover too much. There are here transmission systems and distribution systems. The protective apparatus per power unit on a distribution system will be entirely different from the protective apparatus on a transmission system, and I believe from what appears on this tabulation that such a readjustment of the results would be entirely possible and the information reached rendered thereby a little more satisfactory.

I wish it understood that the forgeoing remarks are merely of details, and are made suggestively to help secure even more satisfactory results in the coming years, rather than in anywise to condemn the report, for this would be most unmerited. The committee should indeed be complimented on the quality of its work.

Mr. H. C. Wirt (Schenectady, N. Y.): The paper is very excellent, as it gives data that a manufacturer can not very well give as to the comparative results on several different types of arresters. The data given show that the various arresters operate about equally well, and it would be difficult from the paper to see along what lines we could work to get improvement. Take the question of the choke-coil, which has been discussed more or less for a great many years—the data secured are about half one way and half the other, and it is difficult to know from the reports considered whether it should be used or not. I believe the last speaker suggested that the investigation should be divided between moderate voltage and high voltage. I should say that 5000 volts and lower should be kept in a distinct class and data secured on the operation of both classes.

Mention is made in the paper that very rarely has trouble occurred from static electricity, which I take to mean troubles

that may exist on the system due to normal operating conditions. I know of several instances important to operating companies. In one case a current transformer grounded and about 45,000-kilowatt capacity was shut down. I believe most companies do not like to talk about their troubles, but if they all reported them the trouble due to static effects would be found to be a serious matter. I have knowledge of one or two systems where they are operating cables, and apparently these troubles are nearly continuous—thirty or forty occurring during a very brief period.

The very fact that this association has appointed a committee for two years to look into these troubles indicates that they are serious. I think most manufacturers of lightning arresters, if they are perfectly frank, admit they can not wholly protect the system from these troubles. There have been many statistics published recently regarding these troubles, and I believe we are going to have some solution of the problem.

THE PRESIDENT: We will now hear the paper on the *Grounding of Secondary Alternating-Current Services,* by Mr. Sidney Hosmer, of Boston. As Mr. Hosmer is not present, Mr. C. H. Herrick will read the paper.

The following paper was read by Mr. Herrick:

GROUNDING SECONDARY ALTERNATING-CURRENT SERVICES

In the spring of 1905 the Edison Electric Illuminating Company of Boston, as a result of an increasing number of accidents and the removal of the bar previously maintained by the insurance interests, determined upon the policy of grounding all alternating-current services, at that time numbering about 5500, scattered over fifteen towns. After some deliberation as to method, it was thought that the best and cheapest way to do this would be by connecting each service with the nearest water pipe in the building.

This arrangement made necessary the obtaining of permission from the householder—a rather laborious process—and, as the insurance interests thought best to require the wire run on the outside of buildings, it did not add to the appearance of the houses. Before undertaking it, therefore, the effort was made to ground in the street at the transformer. A large number of trials of this method over our entire territory demonstrated that it would be impossible to get satisfactory grounds at any reasonable expense. These trials were made by digging and by driving, going as far down as 40 feet. It was then decided that all services where less than twenty were supplied from one transformer or main should be grounded individually on water pipes and larger groups should be left for further investigation and trial of street ground. Our requirements for street grounds were that each should be tested and should be able to blow a six-ampere fuse on 115 volts. Up to the present time we have found that it was impossible to obtain these grounds except in a few places, and I believe it will be necessary to abandon this method entirely.

Having arrived at the conclusion that we would ground individual services, various conferences were held with the insurance interests and with the municipal authorities having jurisdiction, and certain detail rules were formulated by some of them as to the treatment of the ground wire in buildings.

In general, these rules required the following:

(1) All installations to be tested and if below insulation

requirements of the underwriters' general rules they could not be grounded nor could any installation fed from same transformer or main. (This requirement was afterward modified to call for a minimum insulation of 10,000 ohms.)

(2) Wire to be treated as an electric light wire, not less than No. 4, and to be run on outside of building as much as possible.

(3) A special clamp for water pipe was prescribed.

Several contractors were then sent out with instructions to install twelve grounds under these rules and submit a flat price per ground for covering all our territory, and two were afterward awarded the contract. Next, the tenant or owner of each building in which a ground was required was visited and permission obtained for doing the work. A certain amount of difficulty was encountered in this stage of the work, but a comparatively small percentage of refusals was received. Where the customer did refuse, he was required to sign a release, accepting the responsibility himself. On new business coming on to our lines, the installation of the ground wire by the building owner is made one of our requirements for service, unless he is willing to sign a release.

In some of the towns the water departments, and in one case a private water company, offered objection. The water departments were in all cases reasonable and ready to investigate and be convinced that it brought no risk to them and they all have been satisfied. The water company refused to discuss, investigate, or argue the matter at all, ordered all grounds removed, and notified its consumers that after January 1, 1906, water service would be discontinued to any house where a ground wire was attached. This town was very nearly all grounded before the water company took that position. About 25 per cent of the consumers have removed their grounds, signing a release to the Edison company, but no action has been taken against the others by the water company.

The insulation test requirement has been the one thing that has caused us the most trouble, as not only is there the labor of making the test, but one bad installation will, of course, prevent grounding all installations fed from the same source.

Practically all our services are grounded now except those held up by low insulation, and these are in the hands of the insurance underwriters to compel correction.

MR. P. H. BARTLETT (Philadelphia): I am very much interested in Mr. Hosmer's paper, particularly as we have done a considerable amount of preliminary work in the same direction in Philadelphia and are at the present time taking up the matter with the insurance interests. The greatest trouble that we anticipate in connection with the grounding of these installations is that they will not come up to the insulation requirements. I should like to ask Mr. Hosmer if any difficulty was experienced in obtaining the concession for 10,000 ohms from the insurance interests, also what percentage of the installations did not come up to these modified requirements. I suppose it is too early to ask what results have been obtained since these services were grounded, and whether or not those results have thus far justified the expense. I note in the supplement to the *National Code,* as issued in April of this year, that the requirements for grounding have been altered and now cover about such a system as the Boston company has installed.

THE PRESIDENT: I am told that no one here can answer this question for the Boston company. This special study was made by Mr. Hosmer. I know that Mr. Morrison, of the New York Edison Company, has made some extensive tests along that line, and he may be able to give us some information.

MR. MORRISON: I am afraid I have not the data on that. We have always grounded our service by two methods: one by plates, which are used very largely, also by a bundle of copper wires—ground wire extending up the poles.

About a year ago, I noticed in looking over some notes in an electrical journal that a verdict had been rendered against an electric-light company in Pennsylvania that had allowed high-tension current to get on an incandescent-lamp socket, resulting in the death of the person who touched it. Realizing the necessity of protecting the public as well as our company from such suits, I made a series of tests on every ground in a large system covering about 75 miles of pole lines and carrying about 4000 kilowatts. Results showed that grounds made in the manner generally in use by electric-light companies were very inadequate. In fact, the resistance of many of the grounds measured 100 ohms or over, which meant that if a current of 20 amperes flowed it would not blow the high-tension fuses at the

generating station, but would cause a voltage of 2000 volts on the customer's premises. Realizing the necessity of improving the situation at once, I made out a map of the system and all the secondary lines, and estimated the cost of extending the existing neutral wires throughout such a system and grounding the neutral wire heavily at the generating station on a large 13-inch salt-water main. We found that the cost for this district would be much less than for that outlined in the paper just read. This may be partly due to the fact that we have a large number of customers on secondary lines and the neutral wires are pretty well extended along the pole lines. We found the cost for grounding about 1500 services by this method amounted to about $2500, which is much less than the cost outlined in this paper, which I understand is approximately $8.00 per connection; this would have cost our company $12,000 instead of $2500, which is quite a saving to the company.

The advantage of this system is that it keeps all troubles that may occur on your own pole lines, and prevents damage in residences or stores that otherwise might occur from current being carried into such premises by a ground wire fastened to the water-pipe. This is especially the case in our district, where there are many wires belonging to other companies which may become crossed with this ground wire. We have had some cases where trolley feeders have become grounded with a neutral wire and have carried a large amount of current into the customer's premises, causing considerable damage. For this reason it seems preferable to keep all such grounds on our own property and not go into the customer's premises, which might involve legal questions as to whether or not the owner had the right to permit the ground wire to be removed from the premises, by signing the release forms mentioned, particularly if an accident afterward happened to one of his tenants.

After laying out for this district the grounded-neutral system I have already described, I planned another system along similar lines for a more outlying section—that of the Yonkers Electric Light and Power Company. At first sight I thought it might be impracticable, as there was very much less kilowatt capacity in this district and consequently fewer secondary lines. The maximum load for the first district—already mentioned—was about 4000 kilowatts and for this district not over 800 kilowatts. An estimate, however, showed that about 95 per cent

of the transformers could be connected to the neutral wire for a cost of about $3000. Of course in such systems we not only connected the transformers on the secondary lines with this neutral wire, but carried the wire along so as to catch every possible transformer through this No. 4 B. and S. wire, which is grounded on the water-pipe in the station.

It may be of interest to some of the members of the association to know the results of the first tests that were made, which showed up the poor grounds in existence. I have already described how the grounds were made, some by plates and some by bundles of wire. The resistance of these grounds ran from 30 ohms to 245 ohms, some of them being 140, 150 and 188. In another district they ran all the way from 53 ohms to 470 ohms.

To make one of the very best grounds I tried taking a copper plate about three feet long by two feet wide, going near the river and burying the plate in accordance with the rules of the fire underwriters, which mentioned that a good ground could be secured by putting coke beneath the plate and filling in with coke over the plate. We made a hole five feet deep in the river bank, threw in a barrel of coke, placing the plate on top of this and then putting in another barrel of coke. On connecting this plate with a transformer supplying current, we found it necessary to raise the potential to 300 volts in order to pass six amperes through the plate to ground, and that on standing on the ground and touching the wire attached to the plate unpleasant shocks occurred. On measuring the voltage that caused this, we found there were 30 or 40 volts between the plate and the ground. It can easily be seen what poor results are obtained by such ground plates.

In large districts, especially where you have a good many secondary lines, you will find it advisable to carry out the idea of extending the neutral wire and thus avoid the expense of grounding each individual transformer on the water-pipes.

THE PRESIDENT: I am sorry Mr. Hosmer is not here, as he has made a number of tests similar to those spoken of by Mr. Morrison, which show that in certain soils the resistance of the ground connection, even when put in in accordance with the *National Code,* runs up into the hundreds of ohms in nearly every case. Only last week I saw the results of a series of tests made by Professor Puffer, of the Massachusetts Institute of

Technology, which showed the same thing, and the conclusion is that such grounds can not be relied upon. It is the opinion, I believe, of both these gentlemen that the only really safe ground is that made by connecting directly to the water-pipe at each service.

We will now take up the report of the committee on the fire hazard of electricity, Mr. H. C. Wirt, chairman.

Mr. Wirt presented the report, as follows:

REPORT OF COMMITTEE ON THE FIRE HAZARD OF ELECTRICITY

A story is told of a young doctor who, having found a saddle under the bed of his patient, diagnosed the case as resulting from having eaten a horse. How many fires of the country, reported as originating from "defective electric wires," have had the cause determined by the same process of reasoning will never be known. That it is a common practice, however, is shown from the following corrections made to two of the reports of the Electrical Bureau of the National Board of Fire Underwriters: "Forty-two fire losses, aggregating $543,782, reported as caused by electricity, have, upon further and more reliable investigation, been found to have been due to other causes. Of these, a $50,000 loss is reported as of incendiary origin; a $75,000 was due to gas explosion; a $10,000 loss was caused by sparks from a locomotive, and a $75,000 fire originated in an oil lamp. Other fires, attributed to electricity, were found to have been caused by hot ashes, coal oil stoves, gas heaters, spontaneous combustion, *et cætera*. The other report of seventy-seven fires was subjected to the following correction: 'Twenty-seven fire losses, aggregating $123,945, reported as due to electricity, have, upon further and more reliable investigation, been found to have been due to other causes.'"

To report a fire as "origin unknown" or "not ascertained" is regarded by some officials as an acknowledgment of ignorance and incompetency. How much more knowing, then, to report "defective insulation"—a cause that can seldom be disproved as it can never be proved.

Of late the fire chiefs and officials of the country are beginning to realize, with a more intimate knowledge of electricity, the absurdity of assigning to electric wires every fire which no other possible case will fit. The report of "origin unknown" is more often given than the evasion "defective insulation:" nevertheless, on the candid statement of many fire authorities hundreds of conflagrations have been laid to the door of electricity, during the last five years or more, when any one of a thousand other causes were as probable and in many cases more so. That much of the

superstition and fear of the electric light wire on the part of the public is chargeable in a measure to the employees of the central station and the electrical contractors, there can be no doubt. The air of importance and the attitude of superior knowledge assumed by many a repair man, when explaining to a customer the possibilities of a "short-circuit" or a "ground," are directly proportionate to the lack of knowledge of the subject by the customer, who has probably witnessed the spectacular but business-like phenomena of the blowing of a fuse. A hungry contractor has been known to scorch or char the wood moulding containing the conductors with a blow-torch, and then to call the customer's attention to the necessity of immediately substituting iron conduit. Many an automatic or mechanical switch has been installed at the service entrance on the advice of the electrician, who profited by the transaction, that the customer might run no risk from this mysterious force which might assert itself in the dead of the night.

Undoubtedly, the widely circulated and incorrect statistics for the year 1902 did much to attract attention to the so-called electrical hazard. A reported total loss of $12,246,130 should have been $5,633,170 by the deduction of two conflagrations of tremendous extent attributed to electricity, the historic fires of Paterson, N. J. and Waterbury, Conn., where the estimated damage at Paterson was $5,500,000 and at Waterbury $1,400,000. It is hardly necessary to go into an exhaustive proof that neither the Paterson nor the Waterbury fire was caused by electric wires; that neither was in any way due to electricity has been accepted as a fact for a year or more. It can be conclusively proven, however, by signed reports and statements of the highest local authorities in both cities, that electric wires were not assigned or even considered by the authorities as the cause of either fire. As a final authority on the subject, the following extracts from letters written by Samuel C. Snagg, Chief Engineer of the Fire Department of Waterbury and John Stagg, Chief Engineer of the Fire Department of Paterson, may be quoted: Speaking of the cause of the Paterson fire, Mr. Stagg says: "The conflagration did not, in our opinion, start from electric light wires. The fire started, from the throwing of an exploded kerosene lamp from a neighboring building by some of the members of a growler party, on the roof of a car barn, and the high wind carried the flame very rapidly over the entire structure."

The cause of the Waterbury fire, as stated by Mr. Snagg, is as follows: "The cause of our great fire I reported as cause unknown and in my report will be found the following: 'The origin of both of these fires will, in my opinion, always remain unsolved. A thorough investigation has been made but nothing ascertained that would throw any real light on the cause.' I have never attributed the origin of the fire of February 2, 1902, to electric light wires." Considering this, with a misrepresentation of approximately $7,000,000 under the electric loss column, it is not surprising that the insurance officials and the public have drawn the conclusion that electricity was rapidly becoming a hazard of astonishing proportion.

The use of electricity throughout the country is undoubtedly little appreciated except by those who have looked into the subject. The following table, 1, prepared by President L. B. Marks, and contained in his paper read before the Illuminating Engineering Society, gives an idea of the extent to which it is used for illumination:

TABLE I

APPROXIMATE COST OF ILLUMINATION TO THE CONSUMER PER ANNUM IN THE UNITED STATES (1905)*

Electric light	Between	$100,000,000	and	$120,000,000
Coal and water gas	"	35,000,000	"	40,000,000
Natural gas		1,700,000		
Acetylene	"	2,500,000	"	3,000,000
Oil		60,000,000		

* In the U. S. Census Report on Central Electric Light and Power Stations issued 1905, T. C. Martin gives the following data: Income derived from central stations in United States for year 1902 for sale of current for electric lighting, $70,138,147, of which $25,481,045 is for arc lighting and $44,657,102 for incandescent lighting. The number of arc lamps reported is 419,561. The number of incandescent lamps, 18,194,044. In addition to the above I estimate that there are about 300,000 arc lamps in use in isolated plants. On the basis of three and one-half hours per day, or 1100 hours per year average use per arc, at an average cost of three cents per lamp-hour, the cost of lighting per annum by arcs in isolated plants would amount to $9,900,000.

Of the 45,000,000 or more incandescent lamps sold in the United States in 1905 it is estimated that about 70 per cent, or 31,500,000, were 16-cp lamps; about 7 per cent, or 3,150,000, more than 16-cp, and the balance less than 16-cp. On the basis of the data submitted in the Census Report above referred to, I compute that there were in service last year in isolated plants about the equivalent of 20,000,000 16-cp lamps. At one and one-third hours a day, or about 400 hours per year average use per lamp, at an average cost of 0.3 cent per lamp-hour, the cost of lighting per annum by incandescent lamps in isolated plants would amount to $24,000,000.

According to the Census Bulletin on Manufactures issued January 3, 1902, the value of coal and water gas manufactured in the United States in the year 1900 was $69,432,582. The proportion of fuel gas to illuminating gas is not stated in the Report, but is estimated at about 50 per cent. In the Census Report on natural gas the value of natural gas produced during the year 1902 in the United States is given at $30,867,863. Only a very small percentage of the total consumption was used for lighting purposes. According to Henry L. Doherty the value of natural gas used for illuminating purposes during the year 1905 did not exceed $1,700,000. The figures for acetylene gas were estimated from data received from the Union Carbide Company. The figure for oil was obtained from the statistical department of the Standard Oil Company.

From this table it is fair to assume that the use of electricity very nearly equals the sum of all the other agents used for the purpose of illumination. And by further reference to the following table, II, a record of some 60,000 fires, covering a period of seven years, it will be seen that the fire hazard is undoubtedly less than would be the case if the other forms of illuminants were used in place of electricity, and that the showing is most creditable.

TABLE II

A SEVEN-YEARS' RECORD OF FIRES BY CAUSES
(CONTINENTAL INSURANCE COMPANY)

Cause	1905 Number	1905 Per Cent of Total	1899-1905 Number	1899-1905 Per Cent of Total
Unknown	433	4.63	3,651	6.05
Outside causes, exposures, etc.	1,098	11.72	8,211	13.61
LIGHTNING:				
Live stock	83	.86	711	1.18
Building, etc.	672	7.16	4,240	7.03
Total lightning	755	8.02	4,951	8.21
INCENDIARY:				
Internal by assured	100	1.07	759	1.25
External by tramps, etc.	316	3.38	2,376	3.94
Total incendiary	416	4.45	3,135	5.19
CARELESSNESS:				
Adults	347	3.69	3,036	5.03
Children	85	.91	1,041	1.73
Drunkenness	....	....	29	.05
Matches	1,272	13.56	6,262	10.39
Plumbers, mechanics, etc.	79	.85	541	.89
Cigarette or cigar stub	252	2.68	252	.41
Total carelessness	2,035	21.69	11,161	18.50
LIGHTING:				
Candle	88	.92	473	.78
Gas jets in contact with curtain	383	4.09	2,536	4.21
Lights in show windows	16	.17	178	.29
Kerosene	439	4.70	3,110	5.16
Electric	288	3.07	1,709	2.83
Barns	11	.12	68	.11
Leaking gas pipes	46	.49	340	.56
Gasolene gas machines	30	.30	119	.19
Lamp shades	....	....	70	.12
Total lighting	1,301	13.86	8,603	14.25

Cause	1905 Number	1905 Per Cent of Total	1899-1905 Number	1899-1905 Per Cent of Total
HEATING:				
Defective flues	588	6.27	3,978	6.61
Stoves	522	5.56	3,311	5.52
Gas stoves (previous to 1904 included under stoves)	120	1.28	166	.27
Fireplaces, open grates	176	1.88	1,058	1.75
Steam	21	.23	184	.30
Gasolene stoves	143	1.54	807	1.34
Kerosene oil stoves	80	.85	559	.92
Hot air furnaces	131	1.40	749	1.24
Burning out soot in chimney	96	1.03	478	.79
Stove pipes, defective	55	.59	428	.70
Stove pipes, through walls, roofs, etc.	15	.16	112	.18
Dry kilns	7	.07	69	.12
Dry rooms	3	.03	86	.14
Laundries	....	....	35	.05
Water backs, explosions	8	.08	36	.06
Smoke houses, private	1	.01	14	.02
Smoke houses, public pork	....	....	23	.04
Ovens	25	.26	116	.19
Boiler	50	.53	350	.58
Boiling grease	44	.46	285	.48
Fumigating	6	.06	61	.10
Burning of vaults, Smead (X. C.) system	....	....	1	....
Wood box	....	....	1	....
Total heating	2,091	22.29	12,907	21.40
VACANCY:				
Ordinary	2	.02	19	.03
Temporary	8	.09	49	.08
Total vacancy	10	.11	68	.11
SPARKS:				
Mill chimneys	37	.39	248	.41
Forges and foundry furnaces	....	....	9	.01
From cupola	....	....	3	.01
Locomotives, steam vessels, etc.	70	.74	490	.81
On roofs from chimneys	276	2.95	1,539	2.56
From forest fires	7	.07	20	.03
Threshing machines	2	.02	17	.02
Total sparks	392	4.17	2,326	3.85
Ashes	61	.65	340	.56
Naphtha, gasolene, benzine, etc.	68	.73	306	.50
Fireworks	53	.56	422	.70
Illuminations, wakes, Christmas trees, etc.	26	.27	218	.36
Spontaneous combustion	271	2.90	1,578	2.62
Explosions	22	.23	196	.33

Cause	1905 Number	1905 Per Cent of Total	1899-1905 Number	1899-1905 Per Cent of Total
Sawdust spittoons	6	.06	48	.08
Rats and mice	116	1.24	724	1.20
Pickers	5	.05	43	.07
Steam driers	2	.02	....	.01
Friction	58	.62	325	.53
Natural gas	12	.12	99	.16
Sunlight through glass	2	.02	22	.04
General conflagration	144	1.54	990	1.64
Coffee roaster	....	....	4	.01
Moving-picture machine	2	.02	2	....
Slaking lime	1	.01	1	....
Total number of fires	9,380	....	60,335	....

To reach a fair conclusion on the safety of electricity as compared with other light, heat and power mediums, a territory is selected in which electricity is widely represented. New York city is unquestionably one of the most densely electrically-supplied territories in the world. Hundreds of miles of conductors traverse almost every avenue and side street of Manhattan and The Bronx and thousands of miles of wires radiate through each block of buildings; many structures alone extending over many acres and containing installations larger than are found in many towns throughout the country. Over 150,000 horse-power in motors, hundreds of thousands of arc and incandescent lamps, as well as heating appliances, are here supplied in one of the most congested centres of the country. Surely in this territory the extent of the electrical hazard can be fairly judged. The following table, 3, has been accurately compiled from the official reports of the Fire Department of New York city for the years 1902, 1903, 1904, and 1905, it being assumed that the field has shown its greatest growth during the last four years. In this table are represented not only the other illuminant risks, but common domestic risks as well. In order that a fair idea may be obtained of the danger of electrical equipment compared with that of other ordinary risks, it must be borne in mind that electricity might, with fairness, be compared as well to power mediums, such as boilers, furnaces, and the like, since in the item "Electric light wires, sparks from, or defective" not only is electricity represented as an illuminant, but as a very considerable source of power as well as of heat. Nevertheless, the total supply of electricity, considered as an illuminant alone, it can be readily seen, compares very favorably with other lighting mediums.

TABLE III

Manhattan and The Bronx

CAUSES AND LOSSES BY FIRES—WITH AVERAGES AND PERCENTAGE

	1902		1903		1904		1905		1902-1905				
	No. of Fires	Total Loss	No. of Fires	Total Loss	No. of Fires	Total Loss	No. of Fires	Total Loss	No. of Fires	Total Loss	Av. Loss per Fire	% Total Fires	% Total Loss
Ashes (hot); igniting woodwork, etc.	20	$16,305	34	$1,015	34	$1,605	25	$295	113	$19,220	170	0.42	0.106
Chimneys, fireplaces, flues (defective), grates, etc.; heat from	380	65,710	450	106,230	473	35,072	407	8,993	1,710	216,005	126	6.36	1.197
Candles and tapers, carelessness in use of	334	31,096	322	39,177	342	21,622	250	15,408	1,248	107,303	86	4.64	0.594
Electric light, wires, etc.; sparks from or defective	114	50,231	86	47,679	92	40,210	69	69,490	361	207,610	575	1.34	1.150
Kerosene, naphtha, benzine, gasolene, etc.; explosions or ignition of	80	15,238	103	68,161	71	47,609	98	47,400	352	178,408	507	1.31	0.988
Kerosene oil, used in starting stove fires	6	670	6	220	7	82	2	......	21	972	46	0.08	0.005
Gas—escaping and explosion of	159	11,006	180	5,338	189	8,799	159	14,460	687	39,603	58	2.56	0.219
" lights; igniting curtains, etc.	224	33,798	226	13,844	231	25,972	213	18,147	894	91,761	103	3.32	0.508
" stoves, ranges, radiators, etc.; explosion of or heat from	107	15,485	129	11,897	134	12,254	98	17,163	468	56,799	121	1.74	0.315
Gas—total	490	60,289	535	31,079	554	47,025	470	49,770	2,049	188,163	92	7.63	1.042
Lamps—kerosene, gasolene, etc.; falling, breaking, upsetting, heat from	179	40,208	198	52,049	183	21,272	....	......	560	113,529	203	2.08	0.629
" alcohol, kerosene, etc.; explosion of	49	5,797	34	2,130	25	4,790	158	11,078	266	23,795	89	0.99	0.132
Lamps—total	228	46,005	232	54,179	208	26,062	158	11,078	826	137,324	166	3.07	0.761
Matches—carelessness in the use of	806	249,461	665	110,426	748	72,768	733	68,340	2,952	500,995	170	10.98	2.775
" gnawed by mice or rats	26	28,372	43	35,159	33	3,975	23	4,460	125	71,966	576	0.46	0.399
Matches—total	832	277,833	708	145,585	781	76,743	756	72,800	3,077	572,961	186	11.45	3.174
Sparks—from chimneys, stoves, stove-pipes, etc.	142	73,470	148	8,452	200	22,195	150	6,677	640	110,794	173	2.38	0.614
Stoves—furnaces, stove-pipes, etc.; heat from	317	165,753	371	166,958	428	108,318	429	72,272	1,545	513,301	332	5.75	2.844
" furnaces, grates, etc.; hot coals falling from	36	8,386	25	3,775	23	755	30	3,452	114	16,368	144	0.42	0.091
" kerosene, gasolene, etc.; explosion of	4	3,025	2	75	....	......	....	......	6	3,100	517	0.02	0.017
" kerosene, gasolene, etc., falling, upsetting, heat from	62	6,516	37	4,106	41	5,243	40	7,340	180	23,205	129	0.67	0.128
Thawing out frozen water pipes, gas pipes, etc.	29	2,445	40	1,307	167	24,931	99	24,865	335	53,548	160	1.25	0.297
Total number fires—all causes	5,640	$4,283,111	6,558	$4,164,958	7,282	$4,411,909	7,398	$5,103,419	26,878	$18,053,397	672	....	....

An analysis of these figures, representing as they do the comparative danger of the most common every-day risks in the home. as well as in the public building, is intensely interesting. What is true of New York city, should hold true in proportion the country over. Surely no better territory can be selected than this, in the little island where almost every wall and pavement hides its network of wires alive with current.

Compared with candles, gas and lamps, and the other chief illuminants of the metropolis, as shown at the outside, a comparatively small number of the total fires are due to electricity. In all Manhattan Island and The Bronx, only 361 fires have been caused by electricity in the four years 1902, 1903, 1904, 1905.

TABLE IV

ILLUMINANTS

TOTAL FIRES

Manhattan and The Bronx	1902-1905 (Inclusive)
Candles	1,248
Gas	2,049
Lamps	826
	4,123
Electricity	361

From this comparative showing it can be seen that candles started almost four times, gas about six times, and lamps over twice as many fires as electricity. It is further shown that 11.4 times as many fires were caused by the other three illuminants. In the matter of totals of averages charged to electricity one fact must be borne in mind; it is this, that under present conditions electricity is employed as an illuminant in every first-class building of every description, with very few exceptions. In other words, when a fire is charged to electricity, that fire invariably starts in some valuable property, either an elegant dwelling, a prosperous up-to-date manufacturing plant or a modern public edifice. On the other hand, fires due to candles, lamps, and gas are in most instances started in the poorer and consequently cheaper class of buildings. In spite of this consideration, however, we find electricity making a remarkable showing in total losses beside the other illuminants.

TABLE V

Illuminants

TOTAL LOSS

Manhattan and The Bronx	1902-1905 (Inclusive)
Candles	$107,303
Gas	188,163
Lamps	137,324
	$432,790
Electricity	207,610

From this table it may be seen that electricity shows only slightly above the average losses of the other three illuminants. Lamps and candles, even in the metropolis where one expects to find their use gradually dying out, it will be seen, have caused a total damage of some $37,017 greater than that credited to electricity. In the form of percentages, a remarkable showing of electricity as a safe risk is perhaps even more clearly shown. Of the fires in Manhattan and The Bronx, in the entire four years, only a little over one and a quarter per cent were due to electric wires. The high percentages due to the other illuminants, as shown in the following table, furnish food for deep reflection:

TABLE VI

Illuminants

PERCENTAGE OF TOTAL LOSS

Manhattan and The Bronx	1902-1905 (Inclusive)
Candles	.594
Gas	1.042
Lamps	.761
Total	2.397
Electricity	1.150

When one-sixth of all the fires in the metropolis in four years are due to lamps, candles and gas, and approximately only one-seventy-fifth are due to electricity, the showing is exceedingly gratifying. While electricity caused only a little over one and a quarter per cent of all the fires in Manhattan and The Bronx in four years, it is credited with only a trifle over one per cent of the total losses.

TABLE VII

Illuminants

PERCENTAGE OF TOTAL FIRES

Manhattan and The Bronx	1902-1905 (Inclusive)
Candles	4.64
Gas	7.63
Lamps	3.07
Total	15.34
Electricity	1.34

It can be seen that the percentage of damage due to lamps is well over that of electricity. It can also be seen at a glance that the percentage column for the entire four years with many risks, such as matches, stoves, kerosene, naphtha, benzine and gasolene, gas stoves, defective chimneys and flues, is well up with and in some instances exceeds the percentage of total losses attributed to electricity. In a more general comparison of the hazard of common and every-day risks, the relative safety of electricity is shown very clearly. The following table shows convincingly the place of electricity among other risks. As over eight times as many fires are caused by the handling of matches as are due to electricity; six, five, four and three times as many caused by risks most common in every house, the undoubted safety of the electric light medium for the modern building would seem to be demonstrated beyond question.

TABLE VIII

Total Fires

IN ORDER OF MAGNITUDE

Manhattan and The Bronx	1902-1905 (Inclusive)
(1) Matches; carelessness in use of	2952
(2) Chimneys, fireplaces, flues (defective), grates, etc.; heat from	1710
(3) Cigars, cigarettes, pipes, etc.; smoking of	1690
(4) Stoves, furnaces, stove-pipes, etc.; heat from	1545
(5) Candles and tapers; carelessness in use of	1248
(6) Children playing with fire, matches, etc	1098
(7) Gas-lights; igniting curtains, etc	894
(8) Lamps, kerosene, gasolene, etc.; falling, breaking, upsetting, heat from	826
(9) Gas; escaping and explosion of	687
(10) Sparks from chimneys, stoves, stove-pipes, etc	640
(11) Gas-stoves, ranges, radiators, etc.; explosion of, heat from	468
(12) Meats, fat, glue, etc.; igniting on stove	370
(13) Electric light and wires	361

A glance at the following comparative statement of total losses will show as well the relative small damage due to electrically-caused fires considered with other common risks:

TABLE IX

TOTAL LOSS

IN ORDER OF MAGNITUDE

Manhattan and The Bronx	1902-1905 (Inclusive)
Stoves, furnaces, stove-pipes, etc.	$513,301
Matches; carelessness in the use of	500,995
Chimneys, fireplaces, flues (defective), grates, etc.; heat from	216,005
Electric lights, wires, etc.; sparks from or defective	207,610

In this connection it is interesting to contrast the electrical risk with that of "matches gnawed by rats or mice." How often, comparatively, does one hear of a fire of any magnitude which was started from this source? How inconsiderable is this fire danger deemed by every one, yet almost one-half as many fires were caused by the nibbling rodent in four years as by electricity. Whoever gives a second thought to the chance of a rat or a mouse starting his house afire? Why, then, should the superstitious fear of electricity endure when only twice as many fires in a great city occurred from electricity as from the occasional gnawing of a match. Furthermore, as the following table indicates, the average loss from fires caused by mice and matches is equal to that from fires due to electrical sources:

TABLE X

ELECTRICITY VS. MATCHES GNAWED BY RATS OR MICE

Manhattan and The Bronx	1902-1905 (Inclusive)
TOTAL FIRES	
Matches gnawed by rats or mice	125
Electric lights and wires	361
TOTAL LOSS	
Matches gnawed by rats or mice	$71,966
Electric lights and wires	207,610
AVERAGE LOSS	
Matches gnawed by rats or mice	$576
Electric lights and wires	575

One more comparison suggests itself—that of lamps, the illuminant of a generation ago, with electricity, the modern illuminant.

TABLE XI

LAMPS VS. ELECTRICITY

Manhattan and The Bronx	1902-1905 (Inclusive)
TOTAL FIRES	
Lamps	826
Electricity	361
TOTAL LOSS	
Lamps	$137,324
Electricity	207,610

It can be seen from this table that almost three times as many fires were due to lamps during the four years as were caused by electricity, while the total damage from lamps was almost as great, notwithstanding the general decline of their use.

Many other interesting comparisons might be drawn from the city fire tables to show how small is the hazard of electricity as compared with other illuminants, heating and power mediums.

The item, "Electric lights, wires, *et cætera,* sparks from or defective," compares favorably as a whole with either of the other illuminants, the other sources of heat, or the other power medium, yet in itself it represents all three functions.

In the above report it has not been the object to minimize the fire hazard of electricity, but to show by actual comparison the relation of this hazard to that of other agencies supplying the same general class of service. The excellent showing is no doubt due in a great measure to the careful supervision of this subject by the insurance interests and the municipal authorities.

As shown by the figures, it is fair to assume that the use of electricity as an illuminant now exceeds that of all other mediums; and the careful supervision of installations and the study of the causes of fires started by electricity during the last ten years have given us a knowledge of the means required to minimize such fires. This requires good workmanship and careful installation; but it would seem that the extreme measures sometimes imposed are not necessary. *The National Electrical Code* is now generally accepted as the standard rules for the installation of electric wires and gives very satisfactory methods of procedure in practically all cases. Fortunately these rules are generally accepted throughout the country, and are, in by far the majority of cases, reasonably interpreted by the inspectors. Occa-

sionally instances are found where extreme requirements are imposed on account of an interpretation of the rules which was clearly never intended by the framers, or by the setting up of special requirements which do not exist.

On account of the very excellent showing of electricity as a fire hazard, attention is called to these extreme requirements as being unnecessarily harsh and causing needless expense to the manufacturer, central-station man and the consumer, and making those unfamiliar with the subject unduly apprehensive of fires from electrical causes.

In conclusion, your committee would call attention to the very careful work done by many of the central stations and others interested in this subject in co-operating with the insurance and municipal authorities to secure satisfactory supervision and installation of electrical wires, and much valuable information has been gained by prompt investigation of all fires reported as due to electrical origin, to determine the exact cause and future means of prevention. We, therefore, respectfully suggest that work of this kind systematically and thoroughly carried out by all central-station interests will be of very great benefit in placing this matter properly before the general public and will do much to change the now too frequent practice of attributing fires of unknown origin to electrical causes.

Respectfully submitted,

Committee, H. C. Wirt, Chairman,
C. E. Skinner,
A. A. Pope.

DISCUSSION

The President: Your president invited to this convention the officers of the National Board of Fire Underwriters, and they have sent as their representative the secretary of the Underwriters' Laboratories, of Chicago. I have pleasure in introducing Mr. W. H. Merrill, Jr.

Mr. Merrill: As the compiler of the reports referred to on page 402 of the report of this committee, I should like to have your records show that the corrections referred to are not corrections in the reports of the National Board of Fire Underwriters, as your committee states, but are corrections made in

the reports submitted to the National Board. These reports are received from inspectors, fire departments, fire-insurance patrols, electrical contractors and electric-light companies throughout the United States. The figures here referred to cover those portions of the reports received that are found upon further and more reliable investigation as attributable to other fire causes than electricity. It seems to me advantageous to your interests to have this point brought out, as it is clearly brought out in the reports referred to, and not to permit the misconception that might lodge in your minds from hearing the statement read by your committee.

The statistics given on page 406 of the committee's report are quoted from the published reports of one insurance company —the Continental Insurance Company, of New York. Surely, to obtain accurate statistics the experience of all the companies should be taken into consideration. The Continental Insurance Company—a very large company, doing business the country over—does peculiarly a large farm business, and its statistics have for years shown conclusively that the greatest single cause of fire in its experience is the defective flue. The majority of these farm houses are not lighted by electricity.

On page 409 the statement is made that what is true of New York City—referring to the data obtained by the committee of the fire department's records—should hold true in proportion the country over. There are several facts that tend to show that this conclusion is not justified. New York City has a greater number of buildings of fireproof construction than are found in all the other cities of the United States combined. New York City has a corps of twenty-four inspectors employed by the Board of Fire Underwriters and a large corps employed by the municipal authorities for the purpose of safeguarding the electrical hazard. Only about 20 per cent of the installations the country over are inspected, while practically all of those in New York are covered by the service I refer to. Again, New York is peculiarly a city where it is possible to obtain first-class electrical construction. The people are able to pay for it, the electrical companies are closely co-operating with the inspection departments to obtain it, and the results are probably more favorable than in many other sections.

But, Mr. President, it is not the few inaccuracies in this

report that I judge to be of principal importance to the interests that I represent; it is, rather, the fact that this association has appointed a committee on the fire hazard of electricity—that your association recognizes that such hazard exists. Even accepting your committee's statistics of approximately three per cent of the fires attributable to electricity, you can estimate the losses in the United States from this one cause at nearly $1,000,000 per month.

The present is peculiarly a time when the subject of fire waste should engage every one's thoughtful attention. The $200,-000,000 now being paid to meet the losses in San Francisco is collected from the country at large. The real property represented in San Francisco buildings has vanished. It is not replaced by the payment of insurance moneys, because insurance moneys are simply a tax collected from the many and given to the unfortunate few.

I was greatly interested, Mr. President, in the allusion you made in your opening address to the employment by your association of an expert to look into this subject of fire hazard, serving your interests in various sections of the country, where underpaid inspectors have from time to time, through misconception largely, given interpretations of the rules which were not in accordance with the ideas of the framers of these rules. A competent man serving your interest in that connection will prove extremely valuable to you, not only along the lines of the duties planned for him, but also in bringing home to you truthfully and completely the extent to which the form of energy that you are using for lighting is permitted, through carelessness, ignorance and lack of common safeguards, to go beyond the bounds for which you design its use and become a factor in the destruction of property and sometimes in the loss of life. You have, to begin with, we all admit, the best, the safest, form of energy used for the production of artificial light. As time goes on, it may be possible that through the intelligence of your workers you will bring this energy to the point of perfection that nature has devised, and give us, like the firefly, light without attendant heat. Then the farmer in the wayside hotel can wrap his towel about one of your lamps, as he finds it impossible to blow it out, and the people who desire to warm the bedclothing can use the incan-

descent lamp for a bed-warmer without the disastrous results that we have experienced in many sections. But until that time comes the insurance interests ask your helpful co-operation in the work they have endeavored to do intelligently and carefully through the men they have employed to determine exactly the extent to which this hazard is a factor in their business, and to report to you and others the exact nature of the trouble that their experience shows, in the thought that, when all pull together for the common good, the common good must be conserved.

As your association has grown in numbers during the past few years, it has also grown in breadth of view, and the time has passed, I am sure, when local differences and passing annoyances need enter into our joint consideration of national questions of importance to both of us. Your co-operation in the formulation of the *National Electrical Code* has been of value to us, and your assistance in the enforcement of its provisions is of even greater value.

We do not attempt to overestimate the importance of the electrical fire hazard, and you do not, I am sure, attempt to belittle it. It is the exact truth that we both seek, and the useful lessons to be learned from that truth will be of aid to every one. The argument that, because gasolene causes more fires than electricity, electricity is therefore safe, no longer appeals to you. The fact that we publish the details of electrical fires and do not attempt to publish details of many fires caused by gasolene, you no longer consider an injustice to your industry, as it is generally understood that the only lesson to be learned from the gasolene fire is the old one that this material, if used in a building, will sooner or later cause a fire, while the lesson of the electrical fire is very often a new one, following a new application of this necessary and useful form of energy to the plant of the manufacturer, the window of the storekeeper and the living-rooms of the home. Many of the insurance companies in many sections of the country make a specific increase in their rates of premium wherever gasolene is introduced for any purpose inside buildings, but none, so far as I know, have ever required an increase in rate of premium for an electric light or power equipment properly installed. Is not this advantage worth following up just as closely as your proceedings of yesterday and to-day indicate that you intend to follow other means for the promotion of the business of selling electrical energy?

The proportion of the fire waste chargeable to electricity, which, according to the statistics furnished by your committee, may be estimated somewhere in the neighborhood of $12,000,000 annually, can surely be reduced if you will devote your energies to that end. It is an old saying, but a true one, that "a penny saved is a dollar earned," and the dollar saved by the avoidance of an electrical fire will go, not to the enrichment of the insurance companies, for insurance collections increase and decrease closely following the increase and decrease of the fire waste, but it will go to increase the property values of the country, following which comes an increased demand for electrical energy.

As an added incentive to care in the selection of the kind of equipment that you will choose to connect to your lines, I may refer to cases, with which you are doubtless familiar, where the customer has collected damages from the electric-lighting company in recovery for loss of life or loss by fire alleged to have been due to negligence on its part in supplying current to defective installations.

There is every reason why your interests and the interests of the insurance companies are identical, and I know of no particular in which our paths lie apart. If through my visit with you during this most instructive and enjoyable meeting I can make you feel to some extent that it will be to your benefit that we face this mutual problem of the fire waste shoulder to shoulder with each other, I shall feel generously repaid for the sacrifice of time I have made in leaving affairs of importance and journeying a thousand miles to be with you. And, as an evidence of our good will, I shall be glad to bring the officer whose appointment was referred to in your president's address in touch with all of the correspondence of my office, and place its machinery at his command in the pursuit of his investigations and his business conducted in your behalf.

I thank you again, Mr. President, for the invitation extended by you to our people, permitting their representative to attend your deliberations, and for the opportunity you have given me to speak on the subject of principal importance to us.

THE PRESIDENT: I now wish to present to you a gentleman who needs no introduction, the secretary of the National Conference on Standard Electrical Rules, Mr. C. J. H. Woodbury, of Boston.

Mr. Woodbury: I was interested in the report, also in the presentation of the side of the underwriters by Mr. Merrill, of Chicago. The question of inaccuracies in regard to reports of fires ascribed to electricity is broader than that of the quarterly report of the underwriters, as the latter is from a responsible source, in which errors are promptly corrected. The newspapers, however, are prone to be very free in their charges that electricity is the cause of many fires. An instance of this has happened recently, and is not cited in the report of the committee, and that is the fire in San Francisco. Two men who have returned from San Francisco have given me an entirely different account of the cause of the fires (and in presenting this to you I wish either confirmation or correction from any one present who was at San Francisco), and that was that the first effect of the earthquake disabled the central electric stations, and that the isolated plants had not been started up, so that there was not any current in the wires to start fires, but that the fires were very largely due to the shattering of chimneys at a time when the boilers were being fired up for running elevators and for other work.

The number of possible causes of fires is an essential part of any statistics bearing on the number of fires. I believe that if the number of electric lights, the number of kerosene lamps and the number of gas jets used in that property cited in the report could have been tabulated, the results would have been even more in favor of electric lights; that is to say, the final percentage of electricity as a cause of fire in the results of the experience tables of the Continental Insurance Company would have been diminished.

As an example of how safely electricity can be applied for illumination, we can cite the experience of the Factory Mill Mutual Insurance companies, engaged in insurance largely on cotton and woolen mills, both of which are normally hazardous processes. During a period of fourteen years there was not a known fire in all of this $500,000,000 worth of property that was ascribed to electric lighting. On account of a change to other business, I have not had personal knowledge of this remarkable experience during recent years in which the amount of manufacturing property insured by this aggregation of companies has more than doubled and the use of electricity for lighting has increased in far greater ratio until it has become prac-

tically universal, but I am informed that they have never suffered a serious loss from a fire considered to have originated from electricity.

Furthermore, the two sides of every matter should be placed before us, and when the relation of electricity to the fire hazard is considered we must not neglect the results of electricity in the prevention of excessive fire losses by its use in the fire-alarm telegraph system, as well as in telephony—for every telephone is a fire alarm—and it is the great development of these applications of electricity for giving prompt information of fires that has to such an extent warranted the general use of wood in the construction of the cities, towns and villages throughout the country to an extent that has been unequaled on the other side of the Atlantic.

THE PRESIDENT: We have a few minutes that may be devoted to the discussion of the paper presented this morning on *Free Installation of Electric Signs.*

MR. PERCY INGALLS (Newark, N. J.): I wish to ask Mr. Gilchrist a question in regard to the patrol system of which he spoke. He did not cover the question of turning the signs on by patrol. Do the patrolmen turn the signs on as well as turn them off?

MR. GILCHRIST: In our practice in Chicago we cover the congested portion of the city, where there are likely to be a great many customers in a small area, by patrolmen who switch on as well as switch off the signs. These patrolmen switch the signs on at dusk and switch them off either at ten o'clock or at midnight, according to the contract of the customer. We have found that a patrolman in the central section of the city can switch on, and later switch off, 100 signs with ease. To such men we pay about $60 per month, so that the cost of patrolling runs about 60 cents per sign per month. In the outer districts it is the uniform practice to place the signs on a meter-basis system, in which the consumer guarantees a certain amount of income monthly and switches on and switches off his own sign.

MR. INGALLS: In the Public Service territory we have some 636 free signs that we have put out entirely on a meter basis, charging our regular rates for current and requiring a minimum varying from $5.00 to $15 per month, depending upon the size of

the sign. We require a minimum of $5.00 per month from 24-lamp panel signs. We find that this spring our revenue is aggregating about $7000 per month, or a total of about $60,000 a year from 600 signs. The increase in this business has been very rapid indeed. We have advertised it and put special solicitors on, and the results are surprisingly good. We have found in our practice that where we make a minimum monthly charge we are getting a very much higher rate for our current than we are supposedly charging. For example, in the month of April our revenue was $6680, and the average rate, due to the fact that many customers paid several dollars to make up their minimum, was about 22 cents per kilowatt-hour. I do not pretend to say that this is good practice when your rate is 10 or 12 cents. We have practically decided to adopt the patrol system and put all of our signs on a flat rate, and we believe we shall obtain more satisfactory results in this way.

Mr. E. W. Lloyd (Chicago): It may be interesting to the members to know the extent of the sign business in Chicago, and what a large amount of revenue comes from that business in the course of a year. The business brings us a revenue of approximately $300,000 per year. We have over 3000 signs on our system, and in the past month nine solicitors contracted for 162 signs. These contracts are on a two-year basis, and the net revenue from the month's business amounts to $26,700. These solicitors are specially trained in their work and work on a small salary and commission basis. This year they have been allowed a commission amounting to the first week's revenue from the sign, with a minimum commission of $2.50 per sign in addition to the solicitor's salary.

(The meeting then adjourned to executive session.)

ORDER OF BUSINESS

THURSDAY, June 7, 1906

MORNING SESSION, 10.15 A. M.

1. Paper—"Alternating-Current Systems of Distribution and Their Automatic Regulation." By CHARLES W. STONE
2. Paper—"Maintenance and Calibration of Service Meters." By WILLIAM BRADSHAW
3. Paper—"Alternating-Current Elevators." By W. NOBLE DICKINSON, JR.
4. Paper—"Modern Switchboard Practice, with Particular Reference to Automatic Devices." By E. M. HEWLETT
5. Paper—"Control of Motors on Electric Light and Power Circuits." By H. D. JAMES

EVENING SESSION, 8.15 P. M.

Address—"The Agitation for Municipal Ownership in the United States—Its Origin, Meaning and Proper Treatment." By EVERETT W. BURDETT

FIFTH SESSION

President Blood called the meeting to order at a quarter after ten o'clock Thursday morning, and said: "The first paper that we will take up this morning is on *Alternating-Current Systems of Distribution and Their Automatic Regulation,* by Mr. Charles W. Stone, of Schenectady, N. Y."

Mr. Stone read the paper, as follows:

ALTERNATING-CURRENT SYSTEMS OF DISTRIBUTION AND THEIR AUTOMATIC REGULATION

The subject of this paper is so broad that it can only be discussed in a very general way in the limited time at our disposal.

The subject naturally divides into two sections: the first section covering the general subject of primary and secondary distribution, and the second section covering general theory and descriptive matter in regard to the different types of automatic regulators which are now available.

In dealing with the theory of alternating-current distribution, two sides of the system have to be considered: the primary and the secondary. In order that a direct comparison may be made between the different methods of primary and secondary distribution, it seems wise to discuss them separately.

PRIMARY DISTRIBUTION

There are several different systems now in use in this country for primary distribution, and I will take up the five principal ones as follows:

Single-phase,
Two-phase Three-wire,
Two-phase Four-wire,
Three-phase Four-wire,
Three-phase Three-wire.

Single-Phase

The first alternating current used for lighting was all single-phase, and was distributed from the main generating station by means of a number of single-phase feeders which were run to the different sections of the town, feeding individual transformers located near each of the consumers. This system was in many ways very simple to manage and is desirable at present if properly carried out. The principal disadvantage is that it is not well adapted for a power load, except where comparatively small motors are used. If all the generators are run in multiple

and single-phase circuits carried to different sections of the town, and the secondary system is properly designed, individual automatic feeder regulators can be installed and very good regulation can be obtained.

There are now practically no new single-phase systems being installed, and it therefore does not seem desirable to dwell on this subject at any great length.

Two-phase Three-wire

This system is a step in advance over the single-phase, in that it has the great advantage of being able to take care of a power load in addition to the lighting load.

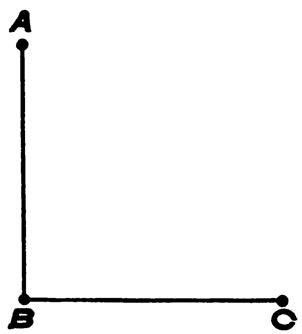


Fig. 1—Two-Phase, Three-Wire System

This system is obtained by connecting together one side of each of the two phases; thus obtaining a third wire which acts as a common return for the two phases.

Two-phase circuits can be run to different sections of the city; the lighting can be distributed on the two phases and power load can be fed from both phases.

The principal objection to such a system is that the load on one phase reacts under certain circumstances in such a way as to affect the other phase, thus making it very difficult to obtain good regulation. The third wire must also be made large enough to carry the resultant current of the two phases. It is therefore forty per cent larger than the other two wires.

Before leaving this method of distribution, I might point out

one other objection, and that is that the potential between the two outside wires is considerably higher than the potential across either of the phases. That is, the potential between wires *A* and *C* on the diagram is $\sqrt{2}$ times the potential between *A* and *B*, and between *B* and *C;* which means a higher potential strain to ground. This means a higher potential without a corresponding decrease in copper.

There are very few systems of this kind now in use in this country, and in most of the places where it has been tried it has been abandoned.

Two-phase Four-wire

This system is very desirable in many ways for both lighting and power. It does not have the disadvantage above mentioned of the two-phase three-wire system, as each phase can be kept independent; lighting can be done single-phase, distributing the different single-phase circuits on the two phases, and carrying the power on both phases. Of course, such a system requires more copper than the three-phase, as all four wires must be carried out for any power load.

The two phases are interconnected at their middle or neutral point in some cases; thus making it possible to ground this point, and thereby maintaining the potential of this point at ground potential.

In other cases both phases are kept absolutely independent.

The first arrangement seems undesirable, on account of the fact that considerable complications are caused in the switchboard and its appliances. If the neutral is not grounded and the two phases are interconnected, simultaneous grounds on any two wires would affect both phases. If the phases are kept entirely separate, a disturbance on one phase need not necessarily affect the other phase, and the switchboard and its appliances can be very much simplified.

It is doubtful if this arrangement is ever as desirable as the three-phase with single-phase lighting feeders.

Three-phase Four-wire

This system has many advantages, the principal one being that it is possible to obtain a higher voltage on the circuit, thus reducing the amount of copper necessary or increasing the distance to which power can be transmitted economically without

having a higher potential on the line between line and ground than would exist on any other system.

This system is obtained by connecting together the three phases of the generators or transformers in Y. Thus the potential across the outside wires is $\sqrt{3}$ times the potential of each individual phase. When the system is balanced the neutral wire carries no current and therefore is usually made smaller than the outside wires.

There are a number of large installations using this system of distribution, such as the Chicago Edison Company in its outlying districts, the Cincinnati Edison Company, the Toledo Traction Company, the Union Heat, Light and Power Company, of Covington, Ky., the Consumers' Light and Power Company, of Duluth, Minn., and others.

The usual practice in such a system is to run single-phase circuits from the station, distributing these single-phase circuits between the outside wires and the neutral. This, however, is not the best arrangement, as the system is designed to take care of large blocks of lighting and power at a considerable distance from the station. If any power load can be obtained, the other two wires are installed, or if a large block of lighting or power can be obtained at some distant point, all four wires are installed, and the lighting can then be distributed between the outside and the neutral wires, and the power can be distributed on all the three phases in the usual manner.

Most of these systems are operated with a grounded neutral. This neutral, however, should be grounded only at the main station, as all kinds of disturbances to telephones, etc., would occur if the neutral is grounded outside the station.

I have recently had called to my attention a peculiar incident which occurred in Milwaukee. This system is a three-phase four-wire grounded neutral system, being grounded not only in the main station but also at the primary of the transformers, and illustrates the troubles which may occur if the neutral of the system is grounded outside of the station. It was noticed that at times a considerable amount of direct current would exist in the lines of the three-phase four-wire alternating system. This matter was investigated and found to be current from the railway system. That is, it was noted that every time a car started up somewhere in the outlying districts, a fluctuation in voltage was noticed on the alternating-current system; thus proving conclusively that the

lines of the three-phase four-wire system were conveying back to the station part of the return current from the railway.

This causes considerable trouble in the lighting transformers and also in the instrument transformers at the main station, as it increases both the magnetizing current and also the *CR* losses and this affects the reading of the instrument.

Three-phase Three-wire

This system, if properly installed, is usually the best method for lighting cities of average size. Less copper is required than in the two-phase four-wire system, and it is also superior in many ways to the two-phase three-wire system.

In laying out a three-phase lighting system, the best method is to make provision so that all circuits leaving the station may be three-phase; each circuit, however, carrying all the lighting on one phase, the third wire being simply for any power work which can be obtained along the line of the feeder. The third wire would not necessarily have to be run at first, and would simply be installed when any power work is developed. It is possible to regulate the lighting phase of this feeder by several different methods, so that extremely good regulation can be obtained, and no attention need be paid to the other two phases.

As the power load on such a circuit increases, the tendency toward balancing the circuit is increased, the motors tending to take current from the other two phases; under certain circumstances, they would even tend to feed back current into the lighting phase. Such an arrangement causes no trouble in the motors unless the unbalancing in potential is considerable.

In order that the unbalancing of the 'bus-bars at the station shall be as small as possible, the lighting fed by the different circuits should be distributed on the different phases. That is, all the lighting on feeder No. 1 should be connected to phase *A*; all the lighting on feeder No. 2 should be connected to phase *B*; all the lighting on feeder No. 3 should be connected to phase *C*; and so on. If the load on the different circuits is not approximately the same, by connecting the lighting load of, say, two small feeders on to one phase and the lighting load of other individual feeders to the other phases, a good balance can be obtained.

If the street lighting is done by a constant-current transformer system of some kind, it is possible to connect this load to

one, or perhaps two, of the phases, and possibly do all the lighting from the third phase, thus obtaining a balanced condition.

Each system, however, will be a separate study by itself, and if the above general rules are observed, there is no reason why the best possible regulation will not be obtained with the fewest number of devices and with the least amount of trouble.

In order to illustrate this method of distribution a little more fully, I am giving you below a diagram (Fig. 2) of the arrangement of the feeders which was adopted in Schenectady, N. Y., when the new station was built. This method of distribution was adopted after giving the matter considerable thought and study, and has proved very satisfactory in every way since its adoption. You will see by the diagram that the main 'bus-

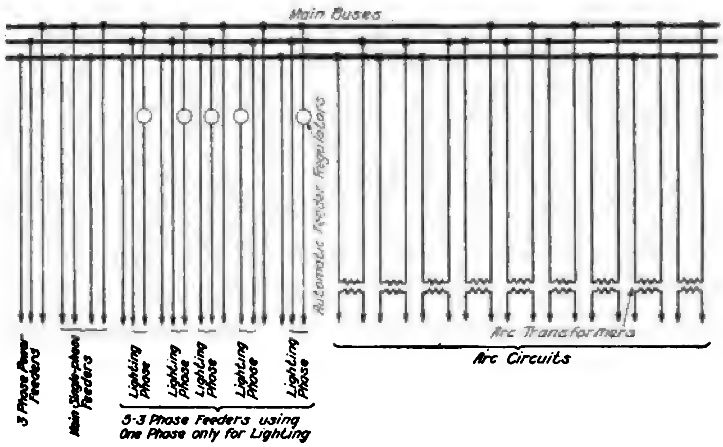


FIG. 2—SYSTEM OF FEEDER CONNECTIONS USED IN SCHENECTADY, N. Y.

bars are three-phase and that there are eight circuits run from the station.

The central portion of the city is fed by two single-phase feeders. These two feeders are run through the main business street of the city; one feeder on each side of the street. As most of the load on these feeders is for stores and shops of different kinds, the peaks correspond almost exactly. These two feeders are run as single-phase feeders and the third wire has never been run, as it proved in this case to be more economical to run a separate three-phase power feeder for this section of the city. Both of these feeders are connected to the same phase of the main station 'bus-bars, and a Tirrill regulator is installed to

regulate the potential of the 'bus-bars and to over-compound for the potential drop of these two feeders.

All the other feeders of the city are run as three-phase feeders; the lighting on each feeder, however, being done entirely from one phase, the third wire being run entirely for the incidental power work, such as ice-cream freezers, small power motors and similar devices. Individual regulators of the automatic type are installed in the lighting phase of each of these feeders.

The arc load is fed entirely by constant-current transformers, and the different transformers are connected to all three of the phases.

By an arrangement such as we have outlined above, you will readily see that the total range of the individual feeder regulators is reduced to a minimum. That is, the total range of regulation necessary on the regulators is determined by the difference in the peaks of the load of the individual feeders and the unbalancing of the main 'bus-bars. In actual practice it was found that the peaks of the different feeders corresponded very closely, and by balancing the system as outlined, the unbalancing in potential of the 'bus-bars was very small, being seldom more than one per cent. Thus the total range necessary on the regulators was very small.

SECONDARY SYSTEMS OF DISTRIBUTION

The secondary side of the system is one that requires very careful consideration and constant watchfulness, in order that proper regulation can be obtained; this is also the part of the system from which, if carefully watched and intelligently administered, the greatest sources of economy can result, both in amount of copper required and in the reduction in core losses of transformers.

The 220 to 110-volt, three-wire secondary system of distribution has proven to be the most satisfactory in almost every particular. The three-wire system is simple and is readily understood by the average operator and lineman. All three wires can be carried into all the customers' premises where the load amounts to more than six to eight lights, thus making it possible to obtain the very best balance; yet the copper required for such a system

is considerably less than that required for a two-wire, low-voltage secondary system.

If the three-wire system of secondary distribution is used, the neutral or middle point of the secondary of the transformer should be grounded. This is advisable from several standpoints, and I presume you are all familiar with the discussions that have taken place in regard to this point. I will, therefore, not enter any further into the discussion of its merits.

If the single-phase primary system is used, the secondary system is very simple, as a complete three-wire network can be installed, and can be fed at different points by the different feeders. If, however, either the two-phase or three-phase systems are used, it is necessary to have a number of different networks; each network being fed by the feeders connected to the different phases of the main 'bus-bars. This has many advantages, also some disadvantages. In case of trouble in any one section, if this section is fed from one phase it does not mean necessarily that any other section of the town that is fed from some other phase of the 'bus-bars is affected. However, on the other hand, the more complete the secondary three-wire network, the better is the regulation.

If the three-phase, three-wire system described above is used, a three-wire network can be fed for lighting from one phase of the feeder, and this network can be fed by single-phase transformers installed at, or as near as possible to, the centre of the load. Other transformers can be installed connected to the other phases for obtaining a third wire for feeding the power load. If the primary of the feeder can be carried into the customer's premises, a three-phase transformer might be installed for the power load. There are, however, some cases where it would be desirable to run a fourth wire around through the section fed by the feeder connected as per the diagram given below.

In planning any system of distribution, it is very important to make such arrangements that it is possible to eliminate the primary line losses by means of regulators. These losses being usually a large proportion of the total losses, by eliminating them it is possible to obtain exceedingly good regulation. Both the three-phase system, with the lighting carried on one phase of each feeder, and the three-phase, four-wire, with the lighting carried on the individual phases connected between the outside wires and

the neutral, are particularly well adapted for the installation of automatic regulators, as direct control can be had of the lighting phase. The secondary being in both cases a single-phase, three-wire system, the control of the lighting phase on the high-tension side of the system means the direct control of the voltage of the three-wire network. It is, therefore, not only possible to compensate for the line loss on the high-potential side of the system, but the effect of the losses on the low-potential side can also be partly eliminated.

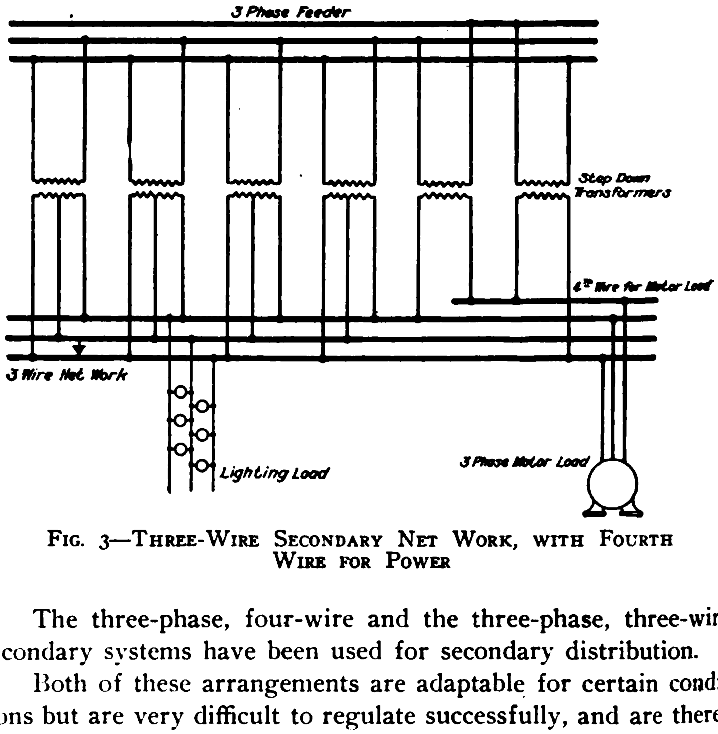


FIG. 3—THREE-WIRE SECONDARY NET WORK, WITH FOURTH WIRE FOR POWER

The three-phase, four-wire and the three-phase, three-wire secondary systems have been used for secondary distribution.

Both of these arrangements are adaptable for certain conditions but are very difficult to regulate successfully, and are therefore not to be recommended except in very special cases.

AUTOMATIC REGULATORS

There are two types of regulators which should be considered under this head:

1st. Regulators that are arranged to work directly or indirectly to change the potential of the generators.

2d. Regulators for operating directly on the feeders.

The most successful type of regulator now in use for regulating the potential of the generator is one that is called the Tirrill regulator. I presume most of you are more or less familiar with its general characteristics, but for the benefit of those who are not, I will endeavor to bring out its general principles of operation.

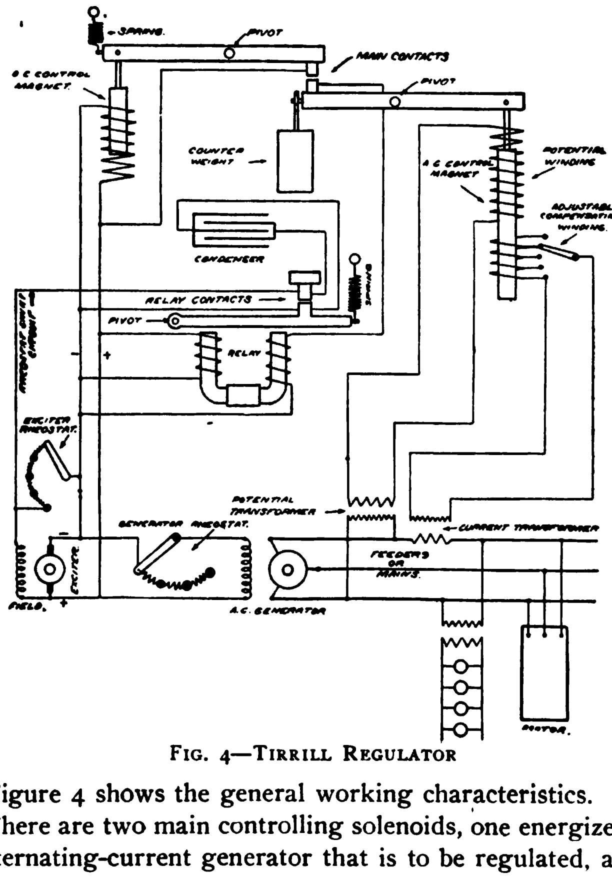


FIG. 4—TIRRILL REGULATOR

Figure 4 shows the general working characteristics.

There are two main controlling solenoids, one energized from the alternating-current generator that is to be regulated, and one energized from the exciter circuit. Each of these solenoids contains a movable iron core which is hung on a balanced lever carrying a platinum point at its other end. When the alternating-current generator is operating with a light load, the exciter voltage is at a minimum, and the pull of the exciter solenoid is therefore much weaker than when the alternating-current generator is fully loaded, and the exciter voltage at a maximum.

It will therefore be seen that the place of contact between the platinum points varies in space relatively to the load carried by the alternating-current generator, and hence it has been very aptly termed a "floating contact."

This primary contact energizes the relay that short-circuits the rheostat in the exciter field. This rheostat is so set that it allows the proper field excitation to generate about 35 per cent of the normal alternator voltage. This amount of excitation was found by experience to give the most satisfactory results when the load is thrown upon the generator. As the voltage drops below normal the resistance is short-circuited by the relay, so bringing the voltage back to normal when it opens again, and so on. It must not be understood, however, that it takes any appreciable time for this change in voltage. The closing and opening of these contacts is accomplished so quickly that there is absolutely no perceptible change in the alternating voltage.

By the application of a simple compounding device to the alternating-current solenoid, any desired voltage can be constantly maintained at a centre of distribution distant from the generating plant, under varying conditions of load, the station voltage being raised and lowered automatically in direct proportion to the current flowing.

Automatic Feeder Regulators

There are two types of automatic feeder regulators now obtainable. Both of these types of regulators are transformers or compensators in principle.

One of these depends on the movement of a dial switch and the other is dependent on the shifting of the magnetic flux through the two coils and cores.

The dial-switch type of regulator is shown in Figure 5. There are two sets of coils which are wound around a core like the core-type transformers. One of the coils is connected across the circuit, and the other coil is connected in series with the circuit, and is provided with a number of taps which are connected to the dial switch.

A dial switch for an automatic regulator must be so designed that it will be light, and thus have little inertia, and must also be rugged in its construction in order to stand the wear and tear of constant operation. It must also be so designed that there will be no burning of the contacts.

This switch consists of three separate parts: the stationary contacts placed on the inside of a cylindrical cast-iron pot; the stationary set of collector rings; the moving part which carries the contact fingers.

FIG. 5—AUTOMATIC FEEDER REGULATOR

The moving part is shown in Figure 6 very clearly, and consists of a metal carrier which has mounted on it ten fingers of different length, all insulated from one another. These fingers bear on the contacts of the stationary part, and are also connected to the ten collector rings on the central stationary part.

By thus designing the contact arms you will readily see that several of these fingers are in contact with the stationary con-

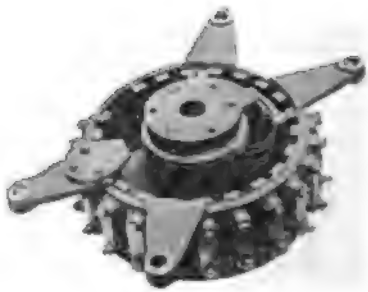


Fig. 6—Switch

tacts at the same time. If these fingers were not insulated from one another, a short-circuit would take place between the taps on

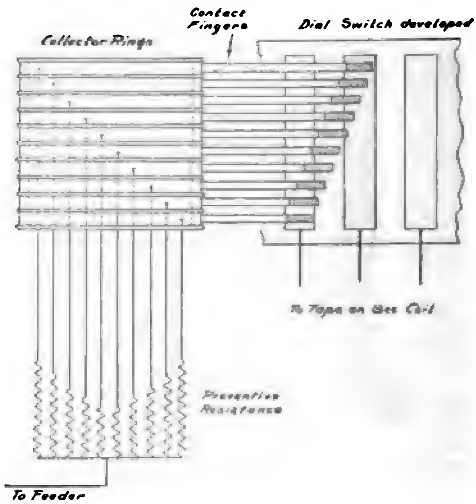


Fig. 7—Diagram of Connections of Switch and Resistance for Automatic C.R. Feeder Regulator

the transformer. They are therefore insulated from one another and a resistance is connected between them. This resistance limits the flow of current between the different taps.

You will see that by this means, several fingers being in contact at all times, no sparking can possibly occur.

Figure 7 clearly shows the systems of connections of this switch.

The operation of this switch is very simple. (See Figure 8.) To the top of the switch arm is attached a beveled gear, and on opposite sides of this gear are two magnetic clutches. A shaft is run through these clutches and on the end is mounted a fly-wheel, which is belted to a motor, or, in case there are a

FIG. 8—COVER OF SWITCH-TYPE REGULATOR

number of regulators, it is belted to a line shaft. This shaft is kept in continual operation; thus if one or other of the magnetic clutches are energized, the pinion attached to it is rotated, and it in turn rotates the switch arm. A limit switch is provided, so that if the switch completes its motion in one direction or the other, the operating circuit of the clutch is opened, which stops the movement of the switch.

The entire moving part of this type of regulator is so small and light that it can respond very quickly, and thus it is impossible to make it hunt.

Figure 5 is a view of the regulator complete, and Figure 9 shows a typical installation of a number of these devices.

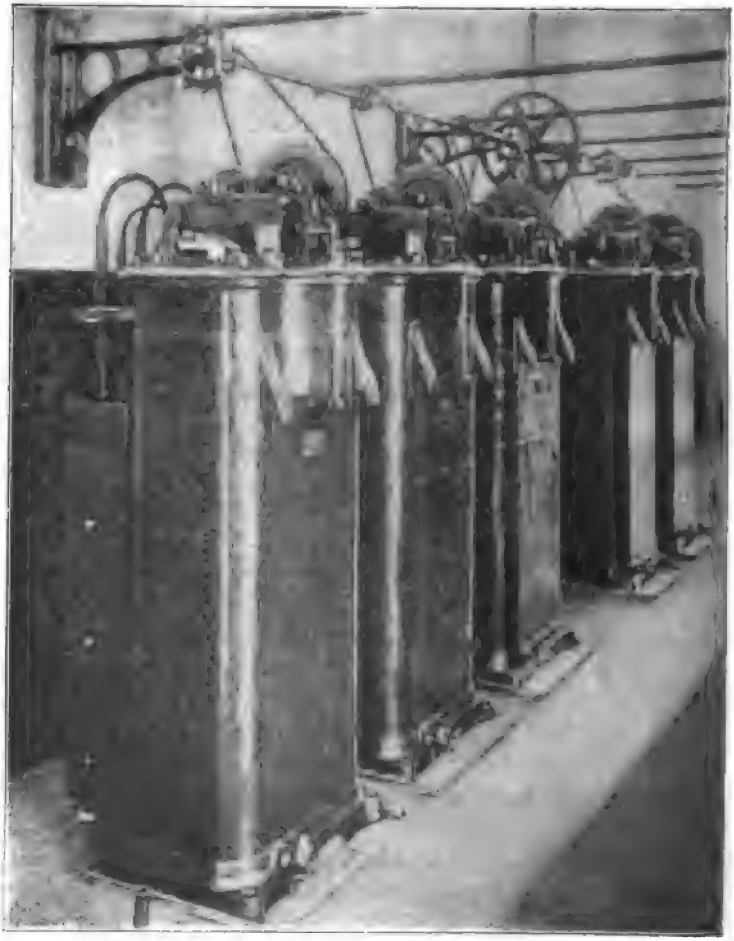


FIG. 9—TYPICAL INSTALLATION OF AUTOMATIC FEEDER REGULATORS

Potential Relay

It is necessary to use a potential relay, which energizes one or the other of the two magnetic clutches. This relay is shown in Figure 10.

It consists of one simple solenoid, in which is placed a movable core. This core is attached to one end of a lever on the other end of which are two platinum contacts. Additional contacts are so placed above and below this lever that any movement of the plunger in the solenoid will close one or the other of these sets of contacts. With the switch type of regulator the closing of one or the other sets of contacts will energize one of the magnetic clutches. With the induction type of regulator, instead of operating directly on the motor circuit, the circuit of either one or the other of the solenoids of the reversing switch is closed.

Figure 11 gives a good idea of the system of connections.

A very simple method of compounding is provided, which is exactly the same as that used on the potential coil of the Tirrill regulator described above.

Automatic Single-Phase Induction Regulators

This type of regulator is built on an entirely different principle from that described above. It is in principle a variable ratio transformer, or rather compensator. The regulator is made with a primary or shunt winding, which is connected across the line. It also has a secondary or series winding, which is connected in series with the line. The primary or shunt winding is placed on a movable core, and the secondary or series winding is placed on the stationary core, as is shown graphically in Figure 12. The shunt winding produces a magnetizing flux that has a constant value, the direction of which is constant in the movable core. But the direction is variable with respect to the secondary core, and consequently with respect to the series or stationary winding. The passing of this flux through the secondary coils in one direction induces a potential in these coils which is added directly to the line potential, or subtracted when the direction of the flux is reversed by rotating the primary core through an angle of 180 degrees. As the core is rotated gradually, the direction of the flux, and consequently the amount forced through the secondary coils, is similarly varied, and produces gradually a varying potential in the secondary from the maximum positive through zero to the maximum negative value.

FIG. 10—POTENTIAL RELAY

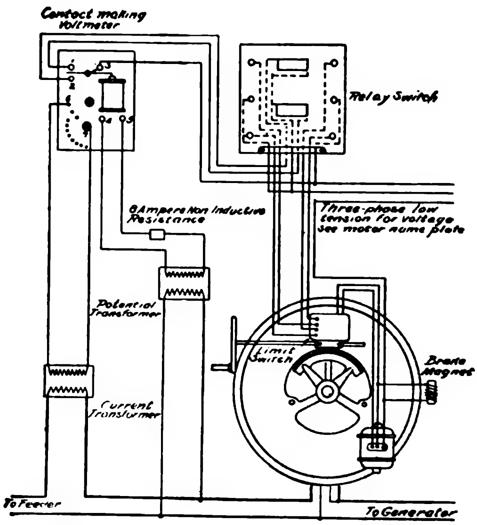


FIG. 11—SYSTEM OF CONNECTIONS

The effect of rotating the core through its entire range is shown graphically in the diagram Figure 13, which shows the variation in the feeder voltage with no-load and full-load current flowing. The slight difference in these curves is due to the loss of the regulator itself, and represents the entire loss of the device.

The rotating core is provided with two windings: the active or shunt winding connected across the lines, and a second winding which is short-circuited on itself and arranged at right angles to the former. The object of this short-circuited winding is to decrease the reactance of the regulator. If the movable core were not provided with a short-circuited winding, and it were rotated from one position to the other, a gradually increased potential would be required to force this current through the series winding; thus causing poor power factor on the feeder.

By adding this winding, however, the reactance of the regulator is cut down to the minimum, and thus has very little effect on the power factor of the line. In this respect it is vastly superior to any of the other resistance and reactance types of regulators heretofore built. The amount of reactive effect on the feeder is directly proportional to the range of regulation of the regulator. That is, as the range in the regulator increases, the effect on the power factor of the circuit is increased; thus with a twenty per cent range on the regulator, the power factor of the feeder would be lowered only a trifle over one per cent, and with a total range of ten per cent, it will be lowered about one-half of one per cent.

The efficiency is extremely high, on account of the fact that the regulators are built on a very small diameter of punching, and are all built with two poles.

The moving mechanism consists of a segment of gunmetal which is keyed to the shaft. This segment engages with a worm gear, which is mounted on the extension of the motor shaft. The motor can be either direct or alternating-current, and is designed to have a very high starting torque in order that the regulator can be started quickly.

A simple magnetic brake is used to bring the regulator to rest quickly.

By referring to the Figures 14 and 15, a good idea of the appearance of the complete regulator and its essential parts can be had.

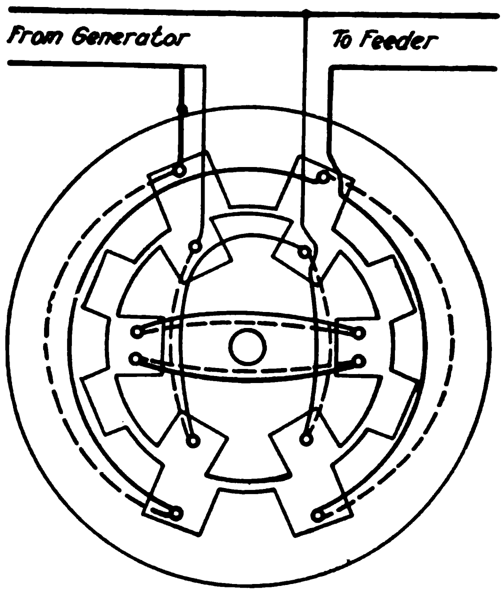


FIG. 12—INDUCTION REGULATOR

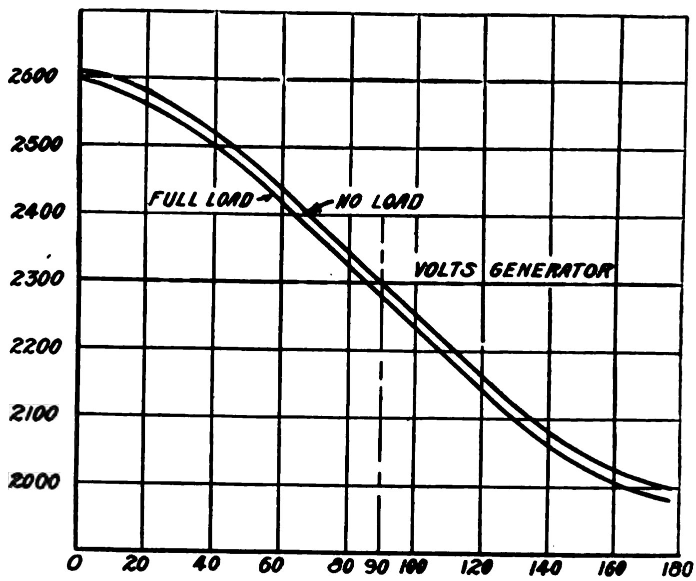


FIG. 13—CURVE OF REGULATION, ROTATION OF ARMATURE IN DEGREES, VOLTS, FEEDER

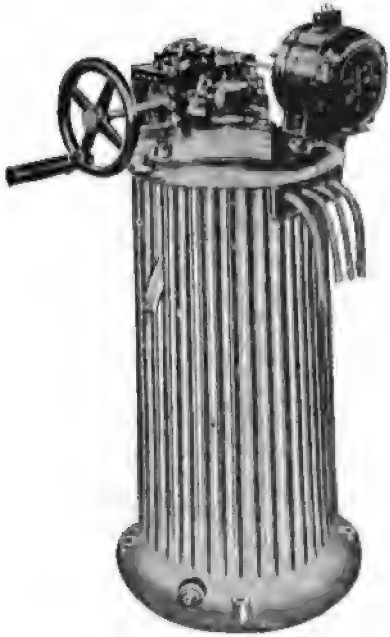


FIG. 14—INDUCTION REGULATOR

FIG. 15—PARTS OF INDUCTION REGULATOR

A reversing switch or relay is used to reverse the direction of the motor. This switch is shown clearly in Figure 16 and needs no further comment.

Mechanically, they are very substantial. The coils are all form-wound and are fitted into the slots in the punchings; they are therefore not subject to any mechanical injury.

A potential relay is used to operate the reversing relay, and is exactly the same as that described above for use with the switch type of regulator.

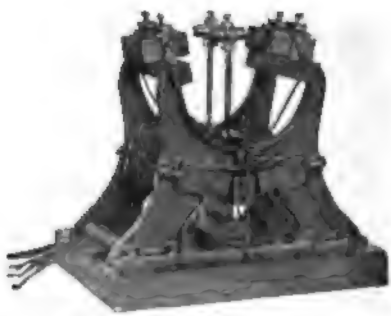


FIG. 16—REVERSING SWITCH

Automatic Three-Phase Regulators

At present there is only one type of automatic three-phase regulator available. This regulator is of the induction type, and is built on exactly the same principle as the single-phase induction regulator described above.

The windings are all three-phase instead of single-phase, and are distributed in the slots on the cores of the stationary and rotating part, in exactly the same manner as on the single-phase.

Regulators of this type are particularly useful when used on transmission circuits to substations. They can be installed either in the main station or in the substation.

If such regulators are used on the main three-phase feeders feeding substations, from which are distributed single-phase light-

ing feeders, it is possible to install automatic single-phase feeder regulators on the different lighting circuits, and thus the very best possible regulation would be obtained.

FIG. 17—THREE-PHASE REGULATOR

Figure 17 gives a good idea of the general outside appearance of regulators of this type.

The above paper is written with the hope that it will provoke discussion. I shall be very glad to answer any questions that may be brought up at this time or later.

DISCUSSION

MR. WALLAU: We are operating in Cleveland an 11,000-volt Y-connected transmission system, and we have a grounded neutral at the main station and at all substations. I should like to ask Mr. Stone if he thinks we should have trouble from stray

currents due to railway circuits with these conditions. There are some other very interesting points brought out in this paper, and I should like to speak of a few of them. Our practice in Cleveland has been to use for primary circuits three-phase, three-wire circuits right straight through. The principal distributing mains are also three-phase, three-wire, but we have some single-phase distributing mains that run down short cross-streets and through back alleys.

The question of secondary distribution has been very forcibly brought home to us by a large number of transformers of small capacity that began to accumulate on our primary systems, and it became necessary for that reason to adopt a definite policy of secondary distribution. In one of our very congested districts on the west side of the city we have a comparatively large area with approximately a 400-kilowatt load at maximum which is distributed entirely underground by a three-phase, four-wire secondary system, the primary being three-phase, three-wire, 2300-volt and the secondary 115-220-volt. As originally installed, this secondary was pretty well balanced, but as new connections are made and customers disconnected we find that our balance becomes quite bad, also that the regulation on that type of secondary is getting to be a very hard thing to maintain. For this reason we have discarded the three-phase, four-wire, except where it exists where we can not very readily change, and have adopted the single-phase three-wire secondary system. Where there are long stretches we balance individual sections; one section of street on a given phase of the feeder, the next section on the next phase, and so on. For small power loads we also install additional transformer capacity, as suggested in this paper. However, we install but one transformer. That is simply to get the other two phases, as the power supplied in these districts is to a large extent very small compared with the total lighting load on the secondary system at that point. We therefore, either connect our transformer to give us 115 volts three-phase where the motors of that type exist, or 230 volts three-phase in addition, when necessary, by connecting the additional transformer with a three-wire connection and running two additional wires. We are about to install a turbine in this connection and put in an exciting set and a Tirrill regulator. We have, however, decided that we could not regulate from one principal

feeder, for the reason that we now have three substations in use and a fourth being built, and the total number of feeders to be supplied by these substations will be something like 33 next fall. We expect that the average load on the feeders will be from 150 to 200 kilowatts, and as the substations are located quite a distance apart it is pretty hard to regulate for any particular feeder and give good regulation on the others. We have, however, adopted the use of compensators, having one compensator cut in each leg of a three-phase primary feeder and one induction regulator in each leg of such feeder. The regulators are motor-operated, but controlled by the station operator, who merely adjusts them to keep his potential balanced as shown on the station voltmeters. We found that we had very little difficulty in obtaining good regulation by this means, and we get rather better efficiency out of our transmission lines, inasmuch as we use the three-phase system, with its resulting economy, as against the single-phase system balanced on a three-phase 'bus.

MR. STONE: I do not think they will have much trouble on the three-phase, grounded-neutral, 110-volt circuit, because I think that the principal trouble occurring on the three-phase, four-wire primary distribution, which I described in the paper, is due to the great number of grounds that are made very close to the railway circuits. I should imagine that with the one ground at the substation, which is probably a considerable distance from the rails and a considerable distance away from the railway circuits, very little trouble would be experienced. I know you were operating with the three-phase, three-wire circuits in Cleveland and getting very good results. I merely think that better, or at least fully as good, results can be obtained with the single-phase system that I have described in the paper, although it is necessary, perhaps, to use a little more copper. Considerable complication can be saved in the main station; that is, if regulation is necessary you can get along with a smaller number of regulators, and a few automatic regulators will pay for a considerable amount of copper.

One thing I tried to bring out in the paper was that with any automatic regulator operating directly on the generator it is not possible to take care of the differences in the peaks on the feeders, but I have suggested that you could take some one

feeder—which may be an important feeder or may be one of a number of important feeders—and regulate for that. That will closely approximate what the other feeders require if they are equally important. If this can not be done, the compounding can be dispensed with and the regulator can be used simply to maintain constant potential; or, if you care to do so, you can install a current transformer in the main 'bus-bar and compound for the whole load.

MR. HALLBERG: In one large power station where they are using the three-phase, four-wire overhead system, with grounded neutral, a great deal of trouble was experienced with the lightning-arrester equipments. Careful consideration should be given to the application of lightning arresters to polyphase alternating-current systems where the neutral is grounded. In such systems the entire circuit potential is always maintained between each phase wire and the ground, therefore an ordinary double-pole lightning arrester, such as can be used for ungrounded systems, should not be used. In the plant referred to above, the double-pole arrester was installed and for a long time much trouble—blowing of fuses, and so forth—would follow every lightning storm, and in some cases the arrester would be demolished. A greater number of gaps in the arresters was tried without overcoming the trouble. Finally it was decided to use single-pole arresters connected in series between each phase wire and the ground, and this arrangement entirely eliminated the trouble. Thereafter no current would follow a discharge from the phase wire to ground, and as the arresters were separated some distance from each other there was no possibility of jumping from the arrester of one phase to the other.

Another interesting matter is the three-phase, four-wire generating system with four-wire, grounded-neutral primary distribution system to all points where heavy loads are concentrated, as may be the case at substations and for special large consumers. In addition to the four-wire, grounded-neutral distribution system for the service above referred to, single-phase primary lines may be run from the power-house or from any substation for regular power and lighting service with single-phase, two-wire or three-wire secondary system of distribution. I believe that a system of this kind is applicable to all classes of work, and self-starting, single-phase motors, ranging from one-eighth

to 40-hp capacity, are now a standard product, and 5-hp to 25-hp single-phase elevator motors have been developed during the past two years and several equipments have been in satisfactory operation during the past ten months. The reduction in the number of switchboard instruments, switches, transformers, motors and wires for such a system is worthy of careful consideration.

MR. J. F. GEISER (Waynesboro, Pa.): I am very much interested in this question of feeder regulators, not because of any experience that we have had with them, but because we are at the present time about to light a park some six miles from our town and we desire to install as simple apparatus as possible for taking care of the losses on the line. We have been looking for just such a regulator as I suppose this one is, and I should like to get as much information as I can about the nature of the apparatus, the amount of attention it requires, and so forth. I would ask Mr. Stone if they are in use at the present time, and if they require frequent inspection or any regular attendance. Our park season is only a few months in the year and we could afford to suffer considerable loss in our feeders for the short period of time if the loss did not disturb our lighting. It seems to me that a feeder regulator of this kind would have a very extended use. I know we have needed things of that kind a great many times in the past, but were unable to get hold of them.

MR. STONE: We have a large number of these automatic regulators in use. There is a large number in Chicago and a number in Toledo. The first regulators that were put out required considerable attention, but at the present time I think we can safely say they require but very little attention and the maintenance should be very slight. With the switch type of regulator there has been practically no wear whatever on the switch after two or three years' continuous operation under commercial conditions. The only maintenance would be to see that the bearings were well oiled and that the contacts on the potential relay were in good condition. If these two things are looked after I anticipate very little trouble to occur in the case of either type of regulator.

THE PRESIDENT: We will now take up the next paper. *Maintenance and Calibration of Service Meters,* by Mr. William Bradshaw, of Pittsburgh.

Mr. Bradshaw presented his paper, as follows:

THE MAINTENANCE AND CALIBRATION OF SERVICE METERS

The importance to the operating company of the satisfactory operation of the service meter needs no emphasis before the convention of the National Electric Light Association. It is but natural that the apparatus which definitely determines the revenue upon which the life of the company depends should and does receive a great deal of attention from the designer, manufacturer and user.

The modern integrating wattmeter has reached a stage in its development where the user's share of attention is reduced to a minimum. Nevertheless, careful and intelligent inspection and calibration are necessary and a never-failing source of revenue.

Maintenance

The efficiency of the maintenance bureau may be materially increased and its cost reduced to a minimum by giving the proper attention to the following points:

(a) The selection of the meter.

(b) The installation of the meter.

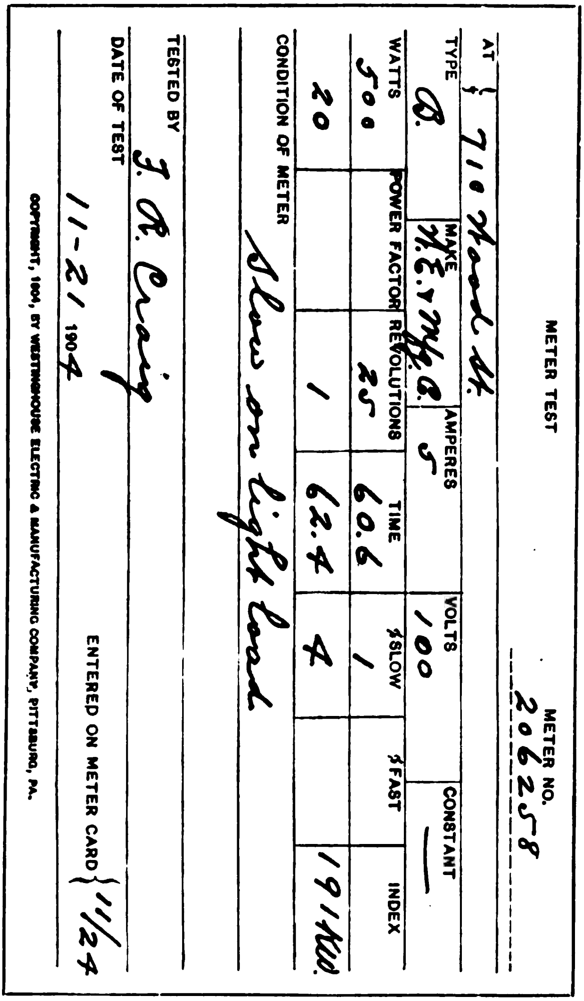
(c) The record system.

Meters should be selected according to the excellence of their mechanical construction and electrical performance. The mechanical features which permit good electrical performance are the lightest moving element consistent with strength, bearings with a minimum of friction and a maximum life; a construction of terminals that provides good surface insulation between opposite sides of the line and to ground and make it difficult to tamper with the registration of the meter; coils, so insulated as to prevent grounding to laminations and burnouts.

Some features affecting the meter's electrical performance are a design of electromagnet that will give a load curve accurate within the limits of plus or minus two per cent from two per cent of full load to 50 per cent overload; a voltage curve accurate within same limits from 50 per cent of voltage to 25 per cent overvoltage; a frequency curve with an accuracy of two per cent for

a change of 10 per cent of alternations. It should have low shunt loss, high ratio of torque to unit weight and a very small change in accuracy for a large change in temperature.

The installation of the meter should take advantage of its


METER TEST

METER NO. 206258

AT 710 Wood St.

TYPE	MAKE	AMPERES	VOLTS	CONSTANT
C.	W.E.&M.Co.	5	100	—

WATTS	POWER FACTOR	REVOLUTIONS	TIME	% SLOW	% FAST	INDEX
500		25	60.6	1		
20		1	62.4	4		191 KW.

CONDITION OF METER Slow on light load

TESTED BY J. R. Craig

DATE OF TEST 11-21 1904

ENTERED ON METER CARD 11/24

FIG. 1—METER RECORD CARD

inherent overload capacity and should be made in an accessible place, free from excessive vibration, moisture, or extreme ranges of temperature.

METER CARD

METER NO. 206258 DATE INV. 1-4-04 MAKE W.E.&Mfg.Co. TYPE B.

MFR'S. NO. 206258 AMP. 5 VOLTS 100 CONST. —

	DATE	ADDRESS CAUSE	INDEX	TEST				READJUSTED
				TRUE WATTS	REV.	TIME	PER CENT REGISTRATION	WITHIN PER CENT
INSTALLED	'04. 1/8	710 Wood St.	KW. 0.	500	25	59.8	100.3	
				20	1	60.0	100.0	
				500	25	60.0	100.0	
REMOVED	11/24	Do.	194	20	1	61.5	97.5	Two.
INSTALLED	11/30	Do.	"	500	25	60.0	100.0	
				20	1	60.5	99.2	
INSTALLED								
REMOVED								
INSTALLED								
REMOVED								
INSTALLED								
REMOVED								

FIG. 2—METER RECORD CARD

The maintenance bureau will have for its principal work a periodic inspection and test of its service meters. This can only be accurately and well done when properly systematized. Record cards, giving the head of the meter department at a glance the condition of the entire meter equipment, should be used. Note cards illustrated herewith.

Calibration

The most efficient and cheapest method of making the periodic inspection and test consists in using such apparatus for the line test that the services of but one man capable of performing both inspection and test are required.

Secondary standards with which the line test can be easily and accurately made are now available in the form of special integrating wattmeters, variously known as test meters, master meters and portable standard integrating meters.

The method of this line test consists in comparing the speeds of the moving element of the service meter and the standard. When used with discretion, it is the most accurate and reliable method available. The special integrating meter should never be considered as anything but a secondary standard and then only when its calibration is frequently checked by a reliable and accurate primary standard.

The laboratory work will consist, first, of test and repairs on service meters, the line test and inspection of which have indicated the need of more extensive repairs and calibration than can be made at the installation; second, of the care and calibration of the secondary standards. The most important and vital work of the maintenance bureau and laboratory of the central station is the proper use and calibration of the secondary standards and the care and use of the primary standard.

The calibration of the secondary standard is made with the primary standard and should include its load and voltage curve as per Figure 3. If the standard is to be used for calibrating service meters of a different type than the standard, its calibration should include the change of registration for changes of frequency.

The method of calibrating service meters by means of the rotary standard is so simple that many make the mistake of thinking that all that is necessary to make the proper check on the

meter under test is to compare its speed with the standard. If the service meter and standard are of the same type and capacity, a comparison of speeds indicates directly the accuracy of the meter under test; however, if of different types they will have different characteristics and hence give different registration for

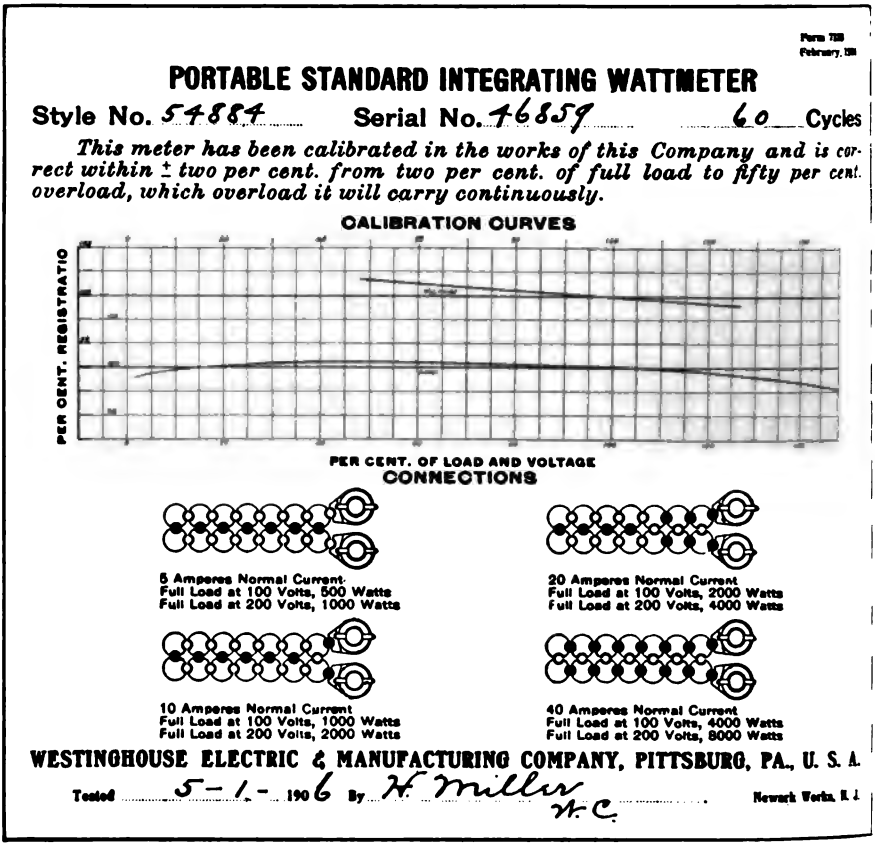


FIG. 3—METER CALIBRATION CURVES

the same loads or for variation from normal of the voltage, frequency or temperature, as will be illustrated by Figures 4 and 5.

Corrections must be made in the reading taken during test for this different percentage registration or serious error will be made in setting the meter under test.

The loads at which the calibration of the service meter is

made will also materially affect the accuracy of its calibration. The usual line tests are 0.1 and full load. The full-load calibration being made by moving the permanent magnets and the 0.1-load calibration by the friction compensation. The closest possible setting by this means at 0.1-load may give an error of from 6 to 12 per cent at 0.02-load and may even make the meter creep on voltage alone. Hence with the modern meter the line calibration at light load should be made at 0.04 load or below.

The construction of the secondary standard will also affect the meter calibration. The standard should have several different capacities of series coils; their normal capacity corresponding to the normal capacities of the service meters in use. If these capacities do not agree there is another chance of error being

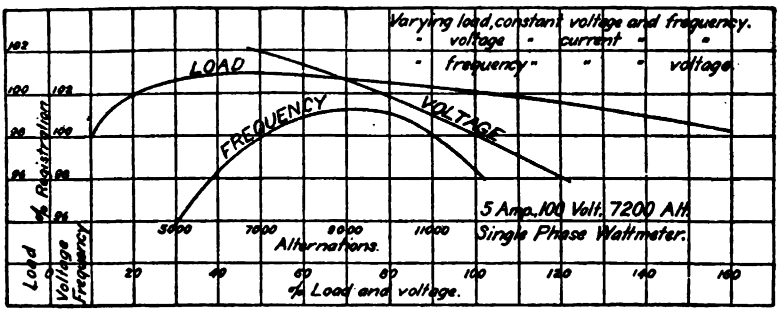


FIG. 4—CURVES ILLUSTRATING VARIATION

made in calibrating the meter. A test should never be made with the meters so arranged as to give nearly full load on the standard and light load on the meter being tested. Each type of integrating meter has a load curve that is not only different, but whose general shape is inherent and not a straight line. Hence the calibration of a meter by a load at one point of the curve and a reading on the standard at another point of the curve may mean an error in the setting of from 0.5 to 1 per cent, or even more.

If the several current capacities are obtained by separate coils for each capacity, it is practically impossible to get the same percentage registration for corresponding points on the load curve of each capacity. Allowance must be made for this differ-

ence or an additional error may be made in the meter setting. However, if there is but one series coil on the standard made up of a number of sections which are connected in series parallel groups for different capacities, there will be no difference in the registration at corresponding points of each capacity load curve and hence no chance for error from this cause.

In selecting a secondary standard choice should be made of the meter which shows the best average performance for both load, voltage and frequency, and the limits of variation should not be greater than specified for service meters.

The primary standard determines the accuracy of the entire bureau's work and its reliability and permanency are of vast importance. The service meters have an inherent range of 75

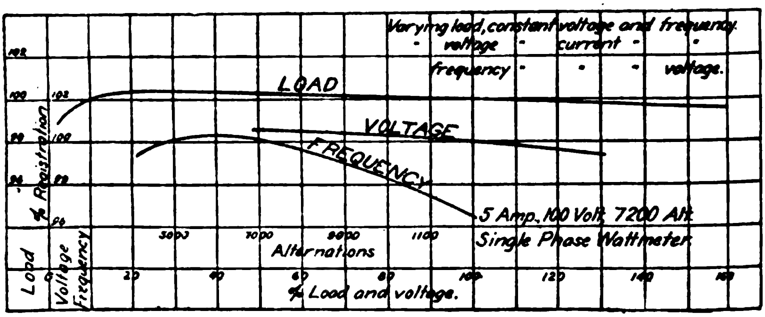


FIG. 5—CURVES ILLUSTRATING VARIATION

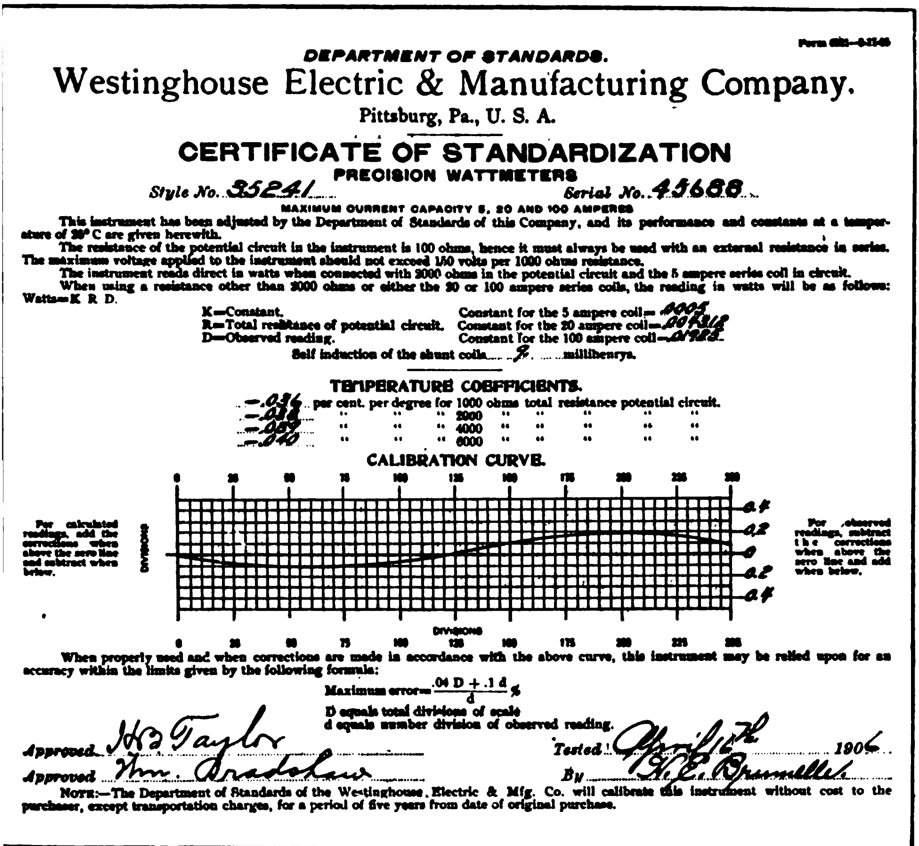
times its smallest calibrated reading and the primary standards must cover the range limits of the entire line of service meters in use by the station.

The manufacturer or some standardizing laboratory should calibrate and maintain the primary standard. The difficulties encountered in both calibration and maintenance are best shown by a detailed description of the calibration of a line of instruments having the extreme ranges required and the requisite accuracy.

There are three classes of errors materially affecting the accuracy of the calibration of electrical instruments: Errors due to unsuitable standards; errors due to vibration or unsteady load, and personal errors. In the method of calibration described an

effort was made to reduce each of these classes of errors to a minimum.

The calibrations are made by comparison with standard cells and standard resistances, which are the fundamental standards for practical purposes. The regular method of calibrating ammeters by measuring the actual current in the instrument windings by means of one or more potentiometers and standard resistances, is also applied to wattmeter and voltmeter calibrations. The shunt circuits of the wattmeters and voltmeters require the same current for their operation, and this fact permits the use of instruments so made as to measure that particular value of current with



DEPARTMENT OF STANDARDS.

Westinghouse Electric & Manufacturing Company.

Pittsburg, Pa., U. S. A.

CERTIFICATE OF STANDARDIZATION

PRECISION WATTMETERS

Style No. 35241 Serial No. 45688

MAXIMUM CURRENT CAPACITY 5, 20 AND 100 AMPERES

This instrument has been adjusted by the Department of Standards of this Company, and its performance and constants at a temperature of 20° C are given herewith.

The resistance of the potential circuit in the instrument is 100 ohms, hence it must always be used with an external resistance in series. The maximum voltage applied to the instrument should not exceed 150 volts per 1000 ohms resistance.

The instrument reads direct in watts when connected with 2000 ohms in the potential circuit and the 5 ampere series coil in circuit.

When using a resistance other than 2000 ohms or either the 20 or 100 ampere series coils, the reading in watts will be as follows: Watts = K R D.

K = Constant. Constant for the 5 ampere coil = .0005
R = Total resistance of potential circuit. Constant for the 20 ampere coil = [illegible]
D = Observed reading. Constant for the 100 ampere coil = [illegible]

Self induction of the shunt coils 9 millihenrys.

TEMPERATURE COEFFICIENTS.

−.036 per cent. per degree for 1000 ohms total resistance potential circuit.
[illegible] " " " 2000 " " " " "
[illegible] " " " 4000 " " " " "
−.040 " " " 6000 " " " " "

CALIBRATION CURVE.

When properly used and when corrections are made in accordance with the above curve, this instrument may be relied upon for an accuracy within the limits given by the following formula:

$$\text{Maximum error} = \frac{.04\,D + .1\,d}{d}\,\%$$

D equals total divisions of scale
d equals number division of observed reading.

Approved H B Taylor Tested April 16th 1906
Approved Wm. Bradshaw By [illegible]

NOTE:—The Department of Standards of the Westinghouse Electric & Mfg. Co. will calibrate this instrument without cost to the purchaser, except transportation charges, for a period of five years from date of original purchase.

FIG. 6—STANDARDIZATION CERTIFICATE

the highest precision. The calibration of the wattmeters is made by two potentiometers, one for measuring the shunt and one the series current.

The potentiometer for measuring the shunt current is adjusted to measure exactly 0.1 ampere, and with the sensitive galvanometer used the slightest deviation from this value is readily detected. The rheostat used for controlling the shunt circuit is arranged for fine adjustment and is so placed that it can be readily operated by the man who reads the two potentiometers. The two sensitive galvanometers used with the calibration of wattmeters have concave mirrors which reflect the light from a Nernst glower on one scale close together, so that observer reading the potentiometers practically controls the entire calibration.

The variations in the voltage of the standard cell for at least two years after they have been set up is practically negligible, seldom exceeding 0.01 per cent. After the voltage begins to vary appreciably the cell is discarded, owing to the liability of serious error being introduced at any moment.

The change in resistance of the wire used as standard resistances is even smaller than the percentage change of the voltage of the standard cell and decreases with age. Manganin wire properly aged does not change its resistance more than a few thousandths of one per cent in a period of several years.

There is practically no limit to the sensibility obtainable in such measurements, so far as the instruments are concerned. By using sensitive galvanometers and standard resistances with sufficient resistance to give a large drop of voltage with the current to be measured, the sensibility can be made such that a change of .0001 per cent is as easily detected as a change of one per cent is in ordinary commercial measurements.

The refinement obtainable in electrical measurements by use of potentiometers is well known, but they are not adapted for measuring alternating current or unsteady direct current. The ideal instrument for this service is one which approaches the accuracy of the potentiometer and allows the ease and quickness of manipulation necessary in the ordinary station test-room. The calibration of this instrument is made by direct comparison with primary standards of highest possible accuracy and it is used on either direct or alternating current.

The calibration of precision instruments is made with a

degree of accuracy not obtainable anywhere except in a standardizing laboratory especially equipped for very accurate measurements. The current used is taken from storage cells of so much greater capacity than that required for the calibration that its use has no effect on the voltage of the cells used. In taking readings for determining the calibration curve, the meter index is always set to read on some even scale division and the current is then adjusted to produce this reading and measured by means of a potentiometer. Two operators are necessary; one to maintain the current constant at the amount required and the other to read the potentiometers. The whole process is really under the direct observation of the operator in charge of the potentiometers, since with uniformly divided scales the constants, obtained from taking readings at several points on the scale, must agree within the limits of the variations of the torque of the springs. Since there can be no sudden variation in the torque of the spring from a curve approximately varying directly as the deflection, it is evident that any reading which does not, with the other readings, make the slope of this curve gradual is wrong and must be checked. Thus, if either operator makes a mistake, the error is at once apparent from the readings of the potentiometer. The personal error is thus reduced to the extremely improbable chance of a series of errors following a uniform law throughout several consecutive readings.

The variable relation between the deflection of a spring and the torque required to produce it is not generally realized. In the use of ordinary current dynamometers, the assumption is made that the torque is directly proportional to the deflection and the constant is determined by averaging the quotient of the current divided by square root of the deflection obtained from readings at several parts of the uniformly graduated scale.

Such an assumption is accurate for some purposes. However, the error due to it varies with different springs and can be changed for any spring by changing the way in which it is clamped to the instrument and by changing the shape of one or more turns.

The curves Figure 7 are the calibration of several Siemens dynamometers and a precision instrument. The dynamometer curves represent checks on the manufacturer's calibration. The curve showing the minimum deviation from a straight line repre-

sents an average calibration on a commercial precision instrument.

This deviation from a straight line is due to several factors, including every detail in the design of the spring, spring holder and method of their mounting. In calibrating precision instruments the springs are adjusted to approximately the right strength

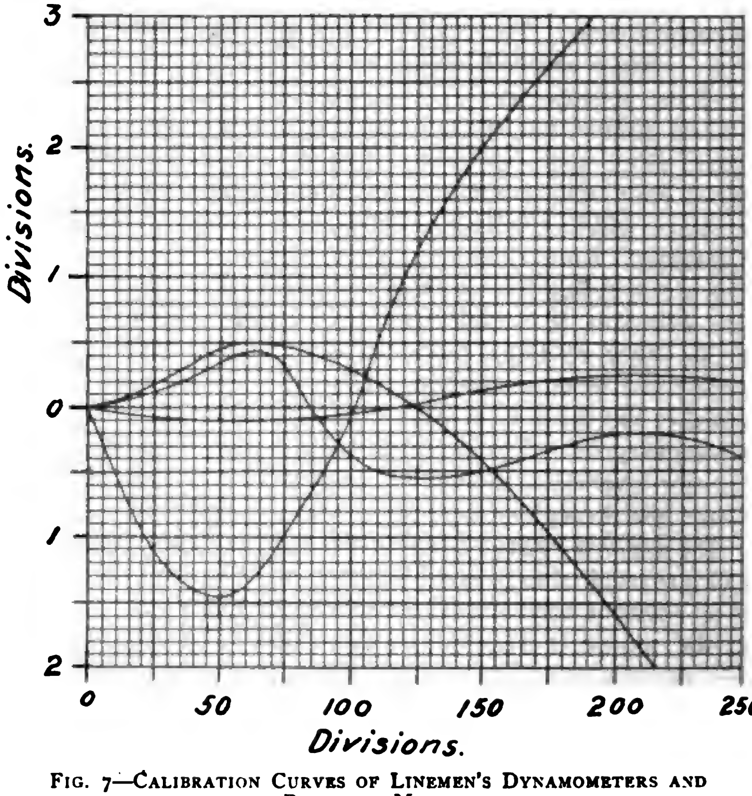


FIG. 7—CALIBRATION CURVES OF LINEMEN'S DYNAMOMETERS AND PRECISION METERS

and a trial calibration curve is made by observing the current corresponding to deflections at four or five points on the scale. A rough curve plotted from these readings indicates whether or not the calibration will be within the limits of the allowable variation. Experience enables the operator to tell from the preliminary curve what adjustment is necessary to improve the cali-

bration when the curve is outside the allowable limits. Occasionally the first adjustment is sufficiently accurate, but the more frequent condition is a final calibration reached after eight or ten trial curves.

Any curve having either large or small variations will repeat itself perfectly at any time, provided no re-adjustment of the springs is made inside the meter. Adjusting the springs so as to make the calibration curve practically a straight line does not affect the accuracy of the meter, except when readings are taken without reference to the curve.

Regarding the accuracy and sensibility of precision instruments, it is found that when the curve is once located, any point can be checked within 0.03 of a division, which is about 0.06 per cent at one-fourth scale and 0.02 per cent at full scale. These check readings must be made with steady current and corrections for temperature. However, their accuracy demonstrates that the only practical limit upon the accuracy obtainable with the instrument is the limit to which personal errors and the uncertainty due to fluctuating load can be reduced.

The difficulty of obtaining readings on unsteady load is not great considering the sensibility of the instrument. It is rendered dead beat by the large controlling force and air damping due to the compact arrangement of the coil system. The zero reading feature is also a help when using the instrument as a standard to measure some predetermined load for which it is set.

In addition to the calibration on direct current, thorough tests are made on alternating current to guard against any defect that might appear more prominent with alternating than direct current. On commercial alternating circuits there is no difficulty in obtaining and maintaining an accuracy well within the limits specified on the certificate Figure 6.

It has been the purpose to emphasize in this paper some essential points in the use of secondary and primary standards which are not generally understood or recognized. The difficulties of properly maintaining and calibrating the meter equipment of a central station are many and serious; nevertheless, they can be overcome by a properly organized and equipped bureau. The organization of the maintenance bureau will depend entirely upon the ability of its head. The equipment will be effective in producing accurate and permanent results in proportion to the

liberality of the financial policy of the operating company. The energetic and progressive company will provide an equipment of primary and secondary standards which are free from the difficulties previously described and meet all the requirements for accurate and permanent work; such standards are available and have demonstrated their accuracy and permanency in commercial service. The proper equipment of standards and intelligent use of the same will always result in a material saving of the company's revenue.

DISCUSSION

MR. J. F. BECKER (Brooklyn, N. Y.): In reference to the paper so ably presented by Mr. Bradshaw, I should like to say that the system outlined has been in use in the Brooklyn Edison Company for the last three years, and with considerable success. The system employed is what is known as the Mowbray test meter, with the multiple windings as described by Mr. Bradshaw. I should like to ask Mr. Bradshaw if this meter could be applied in testing polyphase meters on a three-phase, 25-cycle circuit; power factor being between 10 and 50 per cent. That is the only drawback that we have at the present time to overcome. Under those conditions this meter has not proven satisfactory, and I should like to be advised regarding the matter by Mr. Bradshaw or by other meter men who have had similar conditions to contend with.

MR. BRADSHAW: I see no reason why the meter can not be used to calibrate polyphase meters, provided it is possible to disconnect the polyphase meter and connect it as a single-phase meter. However, to make a line calibration of a polyphase meter under its running condition of inductive loads will require, for accurate work, a polyphase portable integrating wattmeter.

MR. BECKER: I met the difficulty in testing polyphase meters under the conditions mentioned—this meter was subjected to very low power factor—in testing one field at a time, connecting in the standard meter on one field and then going to the other field and connecting on the lagging phase. That is where we met our trouble in getting the mean.

DR. EDWARD WESTON (Newark, N. J.): I should like to ask Mr. Bradshaw whether the curves shown on page 460 are intended to represent the errors due to the spring in the Siemens

dynamometer, or whether they are the combined errors of the instrument. I have had quite a little experience with springs, also with dynamometers, and I certainly found the springs rather more reliable. In fact, you must expect to find in instruments of the dynamometer type errors that are due to other causes than those arising from the springs, especially in the Siemens type of dynamometer, where the coil is immersed in mercury in order to insure contact; but, in addition to that, the Siemens type of dynamometer is not such a type as gives the coil a fixed position with relation to the rest of the field. That induces an error. Springs are extremely accurate and reliable devices if properly made. The best indication of that is that our steamboats, our vessels all over the world, are steered according to time derived from a chronometer, and in that case the spring force varies so minutely that it is practically inappreciable. Of course any difference due to temperature is compensated for by the compensating balance. In the use of springs on time-pieces the error due to the very minute variation of the spring is an accumulative one, for its effect is increased with each beat of the balance-wheel; whereas in using the spring for obtaining a balance, or a condition of equilibrium, that practically does not count at all. The Siemens dynamometer type of instrument is not an unreliable instrument on account of its spring, but on account of the nature of the instrument, the effective character of design and the method of inducing the current through the coils. I venture to say that springs properly constructed will show an error of less than 0.1 per cent, or even 0.01 per cent, but they should not be tested by the application of anything in the way of electrical current or the introduction of a lot of elements that properly do not belong to them mechanically. They should be tested by the application of a weight at a known distance from the centre, which is acting upon a drum carefully counterbalanced at a known distance from the centre.

I should like to make one further remark. Mr. Bradshaw makes the statement that manganin, which I had the pleasure of discovering a good many years ago, and which is being universally used in resistance coils—is constant, and if it shows any change at all it shows a tendency toward decreasing resistance rather than increasing it. That is not the fact; sometimes it goes up and sometimes it goes down, and the variations, while

very small in general, are sometimes quite considerable. It is more marked, apparently, with thin wires than with thick wires, so you must not put too much reliance on manganin standards of resistance, and they must be checked from time to time. We have had some cases of manganin standards that have been in our possession for a matter of perhaps fifteen years that have shown as much as 10 per cent increase. That is a very serious change, but invariably that has occurred with thin wire standards. When it came to thick wire standards the error has generally been very small, but it is not always one way.

I think we may well take exception to a few statements regarding primary and secondary standards used in this paper. I take it for granted you all understand what that means—that this meter, to be used by linemen, and others competent to test integrating meters, is of course a secondary standard, and that it is liable to the same kinds of trouble that arise with all other standards except the absolute standards available in laboratories properly equipped for making checks.

Mr. Bradshaw: In no case was the accuracy of the spring questioned. The statement was made in the paper that, no matter what the curve of the spring might be, a recalibration would always repeat this curve provided no change had been made in the holding of the spring, its location or shape. The accuracy to which I referred was not the spring repeating its curve, but the actual variation of this curve from a straight line. The torque of a spring is not exactly proportional to the deflection obtained in the case of an instrument by putting current through the same. This variation in the torque from the deflection varies with each individual spring, and the curves given in the paper show the accuracy in this respect for several different springs. If the instrument is so constructed as to use only one spring, considerable more variation than 0.1 per cent will be found; but if two springs are used and the calibration is made by a man experienced in the settings of springs, a curve may be obtained that approximates very closely to a straight line, as shown by the calibration curve given in the paper for precision instruments, which was an actual calibration of commercial instruments. The curves showing calibration of various springs represent the accuracy of the spring itself, and not the accuracy of the instrument as suggested by Mr. Weston.

Mr. Weston did not understand my statement regarding manganin wire. The statement was made that manganin wire, properly aged, changed very little and that the amount of this change decreased with age; that is, the longer the wire was in use, the smaller the amount of change. It was not stated that this change was always a decrease. The change may be either an increase or a decrease, either of which will be very slight with wire properly prepared, as stated above.

THE PRESIDENT: We will now proceed to the paper on *Alternating-Current Elevators,* by Mr. W. Noble Dickinson, Jr., of New York City.

The following paper was presented by Mr. Dickinson:

ALTERNATING-CURRENT ELEVATORS

ALTERNATING-CURRENT ELEVATORS.

Elevators for any duty may in some manner be operated from alternating-current circuits; that is, double-belt elevators may be used with continuously running motors, hydraulic elevators may be supplied with pressure by motor-driven pumps, arranged to run continuously, or in some cases, intermittently, and direct-current elevators may be operated through the medium of motor generators, or from storage batteries charged by motor generators or mercury arc rectifiers. Furthermore, the direct-current inductive control lends itself with almost equal readiness to the control of elevators receiving power from direct or alternating-current circuits.

From the general commercial standpoint the desired machine is, however, the direct-connected elevator employing an induction motor. It is, therefore, the direct-connected elevator with which this paper will mainly concern itself.

We have had alternating-current direct-connected elevators for about eight years, or probably the experimental machines date back eleven or twelve years. The early machines were equipped with multiphase motors with mechanical control and were of comparatively low duty, and this same general equipment and duty limitation applies to the majority of alternating-current elevators in operation to-day. For multiphase circuits, motors with either squirrel-cage or definite wound rotors were used, the latter usually carrying collector rings to allow of connection to exterior resistance at starting. The starting resistance was sometimes inserted in the primary circuit of the motor, but more frequently in the secondary or rotor circuit.

The controller generally consisted of a three-pole double-throw switch and, if the first rush of current was to be limited, a device for cutting out the starting resistance. This latter was usually a time element device employing gravity or spring pressure against a dash-pot retardation. This controller in conjunction with a mechanical brake was operated from the car by means

of a hand rope, lever or wheel. The hand-rope controlled direct-connected elevator with squirrel-cage motor is an extremely simple machine, but its application is limited.

The mechanical control served very well for the low-speed commercial machine, but the call for an automatic elevator, that is, one requiring no operator and usually equipped with push-button control for residence service, *et cætera,* demanded a magnetic control. As no satisfactory alternating-current magnet was available, direct-current controlling magnets and brake magnet were employed, and the direct current was obtained from a small motor generator or an aluminum cell rectifier; the elevator motor being retained, however, in the alternating-current form.

The mercury arc rectifier has been considered with respect to the supply of a direct current for these controlling magnets, but the current required to maintain the arc during the period in which no useful work is being done usually represents a loss which is prohibitive. It has been suggested that in hospitals and similar buildings, a few hall lights might be connected with the rectifier in order to make use of the arc-maintaining current, but as any rectifying process is only a half-way step toward the desired results with respect to direct-connected alternating-current elevator operation, action on this line will doubtless be limited.

While a satisfactory alternating-current magnet was not available, it must not be assumed that alternating-current magnets have never been employed. The writer has in mind an elevator in New York city installed in 1899, in connection with which alternating-current controlling and brake magnets were employed and have been in use ever since. The early magnets exhibited, however, several objectionable features. They were noisy, took a large current with an open magnetic circuit, and provided an uncertain electrical contact. The advantage accruing from the employment of magnet control in connection with direct-current elevators made it clear that the perfecting of an alternating-current magnet was distinctly desirable and really essential to any marked advance in the alternating-current elevator field.

We are doubtless all familiar with the groaning sound made by the earlier elevators when starting and the pronounced humming noise while running. These are motor features and have not been so noticeable in later machines and may be eliminated.

The maximum duty of direct-connected alternating-current elevators has always been low, owing to the comparatively large starting current required even with collector-ring motors, and also to the difficulty experienced in stopping. In direct-current elevators the dynamic principle is employed to assist the mechanical friction at the brake shoes in bringing the elevator to rest, and in some cases this dynamic action exerts the greater part of the braking effort. In the ordinary induction motor this dynamic action does not exist after the line current has been cut off, and the braking effort is, therefore, entirely the resultant of mechanical friction. This braking feature is extremely important, as an elevator must be able to come from speed to rest almost instantly, and the car should land within one or two inches of the desired level.

The speed of these elevators has found its maximum practical limitation at about 200 feet per minute. This maximum may be increased about forty per cent by so arranging the motor winding and the controller that the number of magnetic poles in the motor may be doubled when stopping, thus reducing the speed of the motor one-half before finally cutting off the line current and applying the mechanical brake. The employment of such a primary makes necessary, however, the use of a squirrel-cage form of rotor winding, and as this involves very large starting current it is usually prohibitive.

Professor Sever, of Columbia University, made some investigations as to duties, starting current, *et cætera,* of multiphase alternating-current elevators in operation in New York city, and incorporated the results in a paper which appears in the proceedings of the American Institute of Electrical Engineers of April, 1902.

In the United States, but few single-phase direct-connected elevators have been installed. Small elevators, mainly for house service, and using an ordinary multiphase induction motor with a phase splitting arrangement for starting, have operated quietly and quite satisfactorily in so far as service giving is concerned, but the starting current has been large.

Single-phase commutator motors for direct-connected elevators have thus far been employed but little in this country, although in England considerable has been done along this line. That but little has been done here in single-phase work is

no indication that but little will be done, and this single-phase situation will be treated of later.

So much for the general story concerning alternating-current elevators as they have been obtainable until recently. Before taking up the question of the machines that may now be offered by elevator manufacturers, and the possibilities—I might say probabilities—for the near future, it may be well to indicate briefly some of the difficulties that have stood in the path of development of the direct-connected alternating-current elevator.

In the first place, the standard that has been established for direct-connected work by the direct-current elevator is remarkably high, and for this reason a comparative basis of operation exists which did not exist during the early development of the direct-current machine. Again, the alternating-current motor has not been readily obtainable. It has been expensive, and the delays in delivery have militated against experimenting by the elevator manufacturer and have discouraged the elevator customer.

The electric energy consumption demanded by the motors in starting has been considerably in excess of that required by direct-current motors for the same duty, and the introduction of the power factor has augmented the consequent disturbance to the lines. The difficulty experienced in stopping has already been mentioned; while the lack of dynamic action when disconnected from the line, and the liability of reversal of phase relation on the lines of multiphase circuits, raised the question of safety. Furthermore, the noise made by the motors was distinctly objectionable.

Summarized and compared, the application of the alternating-current motor to the regular type of direct-current direct-connected elevator machine, limited the duty of the latter and rendered it expensive to install and to operate. It also made it noisy in operation, detracted from its safety, necessitated mechanical or rectified magnetic control, and affected the lights when placed on a lighting circuit. On the other hand the tendency of central stations toward alternating current made it clear that alternating-current elevators suitable for all classes of service would be called for, and that if real progress was to be made, existing conditions and known principles must be carefully analyzed and the latter applied to the former, singly and in combination, until a basis of

present possibilities was established. This basis should constitute at least an advanced starting point for development.

Applying, in so far as possible, the experience gained in direct-current practice, it followed that the first requirement was a quietly-running motor having a large starting torque per volt-ampere of input, a reasonably small rotor weight, and good efficiency and power factor through a range of load. It further appeared that a motor having direct-current shunt motor characteristics at full speed was necessary and that if possible this motor should be subject to definite speed variation. The multiphase motor, as known, gave better promise than the single-phase motor of fulfilling the conditions, and the multiphase elevator was, therefore, taken up first.

The elimination of noise, the obtaining of an excellent efficiency and power factor at full load, and the reduction of rotor weight and speed to the minimum, could be provided for in the design and manufacture of the motor. The starting torque and speed variation features did not so readily fall into line. The starting torque per volt-ampere was improved, but was not and has not as yet been brought to a point comparable with that of the direct-current motor. Speed variation similar to that obtained by series armature resistance with direct-current motors was available, but, owing to the fact that in direct-connected elevator work, with a given live position of the controller, the motor may be driving the load or the load driving the motor—depending upon the instantaneous relation between the car load and counterweight—it is evident that such speed control is indefinite. Speed variation through a change in the number of poles in a single motor could be obtained, but, as already mentioned in connection with bringing the motor to rest, the use of this device entailed large starting current.

In elevator work the most important consideration is safety, and upon this the certainty with which the maximum speed may be limited and the elevator brought to rest has a direct bearing. The direct-current elevator is considered safe and it remains, therefore, to consider the difference between the application of direct current and alternating current to an elevator machine.

An induction motor has practically the same characteristics as the direct-current shunt motor and, with all resistance cut out of both primary and secondary circuits, the speed of the induction

motor is limited quite as well by the number of cycles on the circuit as the speed of the direct-current motor is limited by the line voltage.

In the event of the line circuit being broken, however, the comparison ceases. Under such conditions the direct-current motor could retain a speed-regulating effect, while the speed of the induction motor would be limited only by the relation existing between the driving force and the mechanical friction opposing it. In small machines this mechanical friction has constituted such a large part of the load that but little difficulty has been experienced from runaways, though centrifugal devices have been added for further protection; but with higher duties the percentage of friction must decrease. It appears, therefore, that with highly efficient gearing and mechanical control, the failure of the current with the machine in operation or the lifting of the brake with no current on the line would prove a source of danger.

The obvious answer to this objection is that the introduction of an electric brake would at once overcome this difficulty, as an electric brake would refuse to release if there were no current on the line, and would immediately set itself in the event of current being shut off during the operation of the elevator; in fact, it would do so more surely than the electric brake on a direct-current machine. Safety, as well as convenience, demanded that an alternating-current magnet control should be available if higher speed or more efficient alternating-current work was to be undertaken, but its design was limited by many conditions.

The imminence of phase reversal on the line is not so apparent as it was some time ago, but it is clear that danger from this source on multiphase circuits exists and always will exist and that provision should be made to nullify its effect. A device which, in the event of reversal of phase relation, shall immediately open the supply circuit and apply the brake or prevent its release, thus bringing the elevator to rest if in operation, or preventing its starting if at rest, best meets this specification. With some mechanical controls the current is cut off from the machine and the brake applied if the car passes the ordinary terminals of travel, and provision is made whereby the same two operations may at any time be performed from the car through some means other than the regular control.

With a magnetic control, perhaps the best device for automat-

ically accomplishing the desired result makes use of the torque principle of a small multiphase motor inserted across the main line circuit. With current across this small motor in the proper relation, the circuit to the elevator controller is complete, but at the instant the phase relation on the main line circuit is reversed, the direction of torque is reversed and the control circuit is, in consequence, opened.

This object may also be accomplished by various applications of direction relation between the power motor and parts of the control. Direction of movement of the control for desired direction of movement of the elevator is definite. Reversal of phase relation would disturb the relation existing between control and elevator direction. Devices mechanically or electrically operated, or operated in combination, may be applied to any part of the elevator system, whereby the elevator is brought to rest immediately this disturbance occurs.

It would seem, therefore, that with proper precautions safety may be assured. It may also be of interest to know that the problem of magnetic control has practically been solved. Something over a year ago a multiphase magnetic control was set up and operated, and its action was positive. Chattering was obviated by the use of four-pole magnets acting on circular armatures. For a two-phase circuit, two U magnets were set at right angles to each other, each having its pole tips the same relative distance from the common armature. Each magnet was wound for a separate phase and its strength varied with the alternations of the current. As one magnet was of maximum strength when the other was zero, and *vice versa,* and both acted on the same armature, the pull on the latter was constant and as this armature carried the moving contact of the control, the contact it made was firm and constant. Furthermore, its attractive action was instantaneous and its release prompt. Magnets of this type may be made as large as desired, and are available for controls or for brake mechanisms.

For ordinary controls, a single-phase magnet of the solenoid type has been developed, which is simpler in construction and wiring, and lends itself more readily to the requirements of a control. Owing to the single-phase winding, the pull on the solenoid core is not steady, and if the contact were secured directly to this core it would chatter and the electrical contact would be uncertain.

To avoid this, the movable contact in the form of a copper disc is sleeved over an extension of the core and supported by a light spring. The energizing of the solenoid coil raises the core and completes the circuit through the movable and stationary contacts. During the time the current is passing through the coil, the core has a longitudinal vibratory motion, due to the alternating nature of the current. The height at which contact occurs and the pressure of the spring are so adjusted that even when the core is at the lowest point of this movement, a firm electrical contact is maintained. This spring principle has also been applied to horizontal magnets with hinged armatures, but the vertical solenoid is the simpler type.

Accelerating magnets may be obtained by using the solenoid type in conjunction with dash-pots to furnish the time element, or by utilizing the differential action between two coils; one energized from the primary circuit, and the other from the secondary circuit of the motor.

With the controller magnets developed, the next step was to reduce the current required to release the brake and, if possible with safety, to provide that the brake-releasing current should not occur simultaneously with the peak of the motor-starting current. It must be remembered that a reduction in voltage on the line affects the torque of an induction motor very seriously, and the motor and the brake should be so related that it would be impossible to release the brake under operating conditions, unless the torque of the motor was sufficient to hold its maximum load. This end has been attained by proper connections in the controller and by the introduction of a momentum type of brake in which the turning effort produced when the friction shoes of the main brake grip the revolving brake-wheel is transmitted to the lever of a second brake which also tends to bring the moving parts to rest. As the braking effort is thus multiplied, a smaller brake magnet meets the requirements, and, in consequence, a smaller brake magnet current.

Utilizing these single-phase control magnets and a multiphase brake magnet, any form of "switch-in-car" or "push-button" control for a multiphase elevator may be obtained, without employing a rectifying process, and it is clear that this same combination is equally applicable to the control of a single-phase elevator by including a phase-splitting device to supply multiphase current to the brake magnet.

The single-phase elevator has not been developed to the same extent as the multiphase elevator, but the limitation is entirely in the motor. At present it is installed mainly for residence service, but higher duty seems quite possible.

Owing to its high starting torque, the single-phase motor which starts as a repulsion motor and runs as an induction motor seems to be the type best adapted to higher duty single-phase elevator service. There are a few elevators in this country thus operated and it is to be hoped that American motor manufacturers will continue the improvement of this type of motor. Foreign manufacturers have succeeded in reducing the noise in the motor, and at present their machines appear to be in the lead so far as motors suitable for direct-connected elevators are concerned. They have also reduced sparking at the commutator without the use of high-resistance leads between the commutator bars and the armature coils, thus diminishing danger of burnout if the motor should fail to start promptly. Furthermore, with the American motor, starting resistance is employed, while from installations including foreign motors it may be eliminated.

Thus, while single-phase apparatus is still somewhat backward, with automatic elevators multiphase operative conditions have been met for a maximum speed of approximately 175 feet per minute and with switch-controlled elevators, a maximum speed of approximately 250 feet per minute, without the use of rectified current, and elevators of these types are now available. For automatic elevators the speed named meets all requirements, but for switch-controlled elevators a speed greater than 250 feet per minute is distinctly desirable.

That such higher speed service is obtainable with a machine which will meet commercial conditions, the writer is thoroughly convinced.

The starting current for an alternating-current motor suitable for elevator work is greater than that of a direct-current motor, but it seems reasonable to assume that in any location in which high-speed service is demanded, provision for a high starting current may be made. It was done when direct-current elevators were new and demanded large starting current, and it will be done for alternating-current elevators. It was justified then. It will be justified now.

It is not difficult to obtain a multiphase induction motor

which shall have large starting torque, or one which shall have either good power factor, high efficiency, good speed regulation, low speed, stability, quiet operation or fairly low rotor weight, but to combine all these features in a single motor is an interesting problem. Compromises must be made and a design which will insure the highest starting torque per volt-ampere and high efficiency at average load seems most fair to both central station and customer, and much has been accomplished toward obtaining a satisfactory motor along these lines. If no better performance can be expected from the motor, high speed apparently means heavy starting current, multi-motors or higher mechanical efficiency in the transmission between motor and load.

High-speed service requires some form of control for intermediate speed, in order that good landings may be made. The introduction of a double or multi-motor arrangement with provision for individual and cascade connection, or with one electrodynamic machine arranged as a power consumer, appears to offer the best promise for definite speed control, but the introduction of the multi-motor also affects the starting torque required and obtainable. By use of the cascade connection increased starting torque for the same volt-ampere input may be obtained, but in stepping from one set of connections to another the current jumps are apt to be large unless the control is complicated, and this situation has been quite thoroughly gone over in the application of the cascade connection to multiphase railroad work.

The cascade arrangement would permit efficient operation at the various speeds and, during the first portion of speed reduction would produce a dynamic braking effect, but, on the other hand, any multi-motor arrangement must naturally increase the weight of the rotor necessary for a given full-speed duty, and the disadvantages of an increase in the weight of the high-speed parts of a direct-connected elevator may not be fully appreciated. For the information of those who have not given thought to this phase of the subject, it may be well to state that with an ordinary direct-connected machine, using both independent and drum counterweight and arranged for a capacity of 2500 pounds at about 300 feet per minute, the inertia value of the high-speed parts—namely, the worm, brake-wheel and rotor—constitutes about eighty-five per cent of that of the entire elevator equipment; in other words, of the excess torque necessary to accelerate the elevator to full

speed when starting, about eighty-five per cent is required to get the rotor, brake-wheel and worm up to speed, while the small balance of from ten per cent to fifteen per cent suffices to bring the car, load and counterweights to speed.

If necessary, the efficiency of the mechanism between the motor and the live load in the car may be increased, thus cutting down the running horse-power required of the motor and, in consequence, the weight of the rotor. This reduces not only the torque required to move the load at constant speed, but also the torque needed to overcome inertia during acceleration.

Mention has already been made of two methods of reducing the maximum starting current by reducing and adjusting the brake current, and still another device includes the mounting of the stator of the motor in bearings concentric with the rotor bearings in such manner that it may revolve through part of a circumference, but, when not energized, will be held central between the limits of its arc of movement. The starting torque itself is thus made to release the brake through a cam on the stator, which acts upon the brake lever. This also provides for safety by interlinking motor torque and brake release, and includes in the same device the motion necessary for a phase reversal safety.

A type of accelerating device which has been advocated with particular reference to the acceleration of large units, employs a small direct-current generator and direct-current magnets. The generator is arranged to be positively driven by the elevator motor and is electrically connected to the accelerating magnets. Rotation of the motor is accompanied by corresponding rotation of the generator, and, as the electromotive force of the latter gradually increases, the accelerating switches consecutively short-circuit sections of rotor resistance until all starting resistance has been cut out. Current from this generator is also employed to assist in stopping, by passing it through an auxiliary brake-applying solenoid at the instant the operating circuit is opened. This is applicable to either multiphase or single-phase apparatus.

The direct-current type of accelerating device employing a magnetic clutch driven from the elevator motor, may be applied to an alternating-current elevator by substituting alternating-current magnets. Any resistance cutout, mechanically driven and employing a magnetic detent, and a holding magnet at the terminus of travel, may be made to accomplish the same object.

A non-chattering magnetic control may also be obtained by arranging for electrical contact through gravity or spring pressure rather than through the direct action of the control magnets. This may be accomplished by allowing the weighted core of a solenoid through which no current is flowing, to hold open the contact. When the coil is energized, the pressure due to the core is removed and firm contact is then established by the action of gravity, or by a spring.

A direct-acting single-phase magnet may be made to insure continuity of circuit by introducing sliding contacts. The vibration due to the alternating current may move the contact, but it does not open the circuit.

Pilot motor controls may also be employed.

Compressed air may be applied to alternating-current elevator control substantially as in alternating-current railroad control.

For stopping, improved mechanical braking devices have been mentioned, and the dynamic action obtainable from multi-motor arrangements may be employed through all or part of the period of stopping, as well as for intermediate speed control. It is evident that the introduction of direct current into the windings on the stator of an induction motor, after the alternating-current supply has been cut off, will produce a dynamic action effective in stopping. With a multi-motor arrangement the application of this scheme to one of the motors is also available for intermediate speed control. The direct current required for this purpose may be obtained from a small direct-current generator mechanically driven by the elevator motor or from an exterior source.

It is no easy task to produce a high-speed alternating-current elevator that shall be satisfactory from every standpoint, but operative principles have been evolved and its development really lies in the hands of the central stations. Mechanically and electrically-controlled elevators for low and medium speeds are now on the market and the higher-speed machines will, I believe, be obtainable if there is a persistent call for them. So long as the high-speed direct-current elevator meets the requirements, so long will the development of the high-speed alternating-current elevator be retarded, for this is a busy world and the work first undertaken is that which is easiest or that for which there is the greatest demand.

W. N. Dickinson, Jr.

DISCUSSION

Mr. Wagoner: I want to make a comment on Mr. Dickinson's statement, appearing on page 467 of his very able paper, regarding the use of mercury arc rectifiers in connection with elevators. Mr. Dickinson makes the statement that the current required to maintain the arc during the period in which no useful work is being done usually represents a loss that is prohibitive. I feel that in this instance the word "prohibitive" is comparative. It is possible to maintain the arc during the period referred to by Mr. Dickinson with a loss of energy not exceeding 100 watts—perhaps something less than that amount—and I feel that there are many cases where the advantage of being able to use direct-current motors would more than offset the energy equivalent of one or two incandescent lamps. Mr. Dickinson refers to the use of the rectifier for elevator service in connection with storage batteries. I feel that it is entirely possible for rectifiers to be applied to this service without the use of any storage battery at all. This belief is founded on the fact that I have seen a trolley car propelled with current furnished by the mercury arc rectifier, in which the energy required was as great as would be required in elevator service, and the character of the load was certainly as fluctuating.

Mr. Dickinson: I am glad to hear from Mr. Wagoner. I had the pleasure of listening to Mr. Wagoner's paper on the mercury arc rectifier read at the convention a year ago, and was much interested. I looked further into the matter at that time, also just before coming here inquired at two offices concerning the amount of energy required to maintain the arc, and gained the idea that it was from 400 to 600 watts. I am interested to learn that it is considered practical to operate elevators through the medium of mercury arc rectifiers, and shall be obliged to Mr. Wagoner if he will communicate with me with reference to any further experiments undertaken in that direction. This matter of alternating-current elevators is quite important, and I shall be glad to hear from any one who has plans mapped out.

Mr. McCabe: Mr. Dickinson states on page 474: "Furthermore, with the American motor, starting resistance is employed, while from installations including foreign motors it may be eliminated." I should like to ask Mr. Dickinson if the American practice of using starting resistances is not to regulate the supply

of current on the circuits on which the alternating-current motor is used; in other words, is it not put there to keep down fluctuations, and if the starting resistance were eliminated would it not be impossible to use lights on the same circuits the motors are operated on?

MR. DICKINSON: With reference to that, the resistance is placed there to cut down the starting current, but on the other side of the water an equal starting torque has been obtained for the same starting current without the use of resistance. In the repulsion motor the starting current is dependent upon several factors—position of brushes as well as the use of resistance. After this type of elevator motor gets up to speed it runs purely as an induction motor.

THE PRESIDENT: Mr. Dickinson referred to a number of engineers who were working on the development of the single-phase motor. One of these gentlemen is with us to-day and I am sure we shall be glad to hear what Mr. Layman has to say to us on this subject.

MR. W. A. LAYMAN (St. Louis): Concerning this matter that Mr. McCabe has brought up, I think I can offer an explanation. For about a year I have been interested to a considerable extent in the adaptation of a single-phase alternating-current motor to elevator work. We have proposed to use the type of motor that I think Mr. Dickinson has had in mind as being employed on the other side. I will say that our motor was designed by the engineer who has been doing much of this European work, and that he came to this country for the purpose of doing this work for us here. We have in our possession one of his European motors, and such modifications as we have made in it in developing a motor for the American market have been for the purpose of producing what we regarded as a more satisfactory motor from the standpoint of American central-station practice.

In all of our installations to date we have employed a starting resistance, because we felt that American central stations would eventually require such a limitation of starting current as would make the use of this resistance inevitable. The same equipments can be employed without starting resistance and the starting currents can be held down to reasonable dimensions, but I think the eventual refinement of the service from the central-station point of view will make the resistance desirable.

It is very fortunate that this paper on alternating-current elevator motors has been presented to this convention by an elevator man of wide experience, and I think Mr. Dickinson is especially happy in the following statement, which I quote from his paper:

"It is no easy task to produce a high-speed alternating-current elevator that shall be satisfactory from every standpoint, but operative principles have been evolved, and its development easily lies in the hands of the central station."

One of the greatest difficulties in the alternating-current elevator situation up to date has been the reluctance of some of the elevator companies to recognize that there existed any demand for the single-phase alternating-current elevator and to concede that the central-station man had anything to do with the elevator situation. I do not mean to suggest that this is the case with Mr. Dickinson and his company, as they are quite evidently keeping in very close touch with the central-station situation. But such is actually the case with quite a number of the elevator companies. Quite recently, in conversation with one of the prominent elevator manufacturers, he made the emphatic statement that his company was not interested in a single-phase elevator motor, as there was no demand for such a device.

The type of motor we have been suggesting for single-phase elevator service has now been on the market in this country for about one year. Equipments have been developed to the point where moderate-speed service can be taken care of nicely, and it is only a question of a short time until, in my judgment, single-phase elevator outfits will be available for practically all kinds of service.

I have been asked since I came to this convention why the introduction of this apparatus was proceeding so slowly. There have been several reasons. In the first place, it is a new line of business for the manufacturers of the motor, and our theory has been that we must educate the elevator manufacturers into the use of the apparatus before too energetically forcing its introduction upon the central-station public. As I have said, the elevator men have taken very little interest in the proposition to date. Some of the manufacturers are reluctant to go into the business until a form of motor has been produced that in

their judgment will do all kinds of service. Others, out of touch with the central-station situation, recognize no necessity for any such type of apparatus and display little interest in qualifying to take care of such a demand until after it has actually materialized—from their point of view. We have had a great many inquiries from central-station people, which we have directed to the elevator manufacturers in their particular vicinity without these makers being willing to undertake the installation. We have continued the effort, however, to qualify the elevator manufacturers, proceeding on the theory that the proper people to install elevator equipments were elevator manufacturers, and not motor manufacturers.

Another reason why this business has proceeded slowly is that it has been our desire to test out the type of motor thoroughly, not caring to foist on the market a gold brick. We have therefore placed on the market twenty to twenty-five equipments, and have been watching them carefully to see what the service results were and how satisfied the central-station people were. We have now satisfied ourselves and think the motor in its present shape is a commercial success and will do moderate-speed work. We are therefore prepared to go ahead with the business, expecting to co-operate with the elevator men in perfecting combinations to take care of a larger variety of service conditions than have thus far been taken care of.

The question has been asked as to the results of single-phase equipments as compared with polyphase, and when the central-station man should put in one as compared with the other. I feel the same principle holds here as in ordinary alternating-current power service. There is an engineering dividing line between the polyphase motor and the single-phase motor for constant-speed service, and this is practically the dividing line between the single-phase and polyphase elevator equipments. After the central-station engineer has determined where he wants to give polyphase and where single-phase service, the question of the type of elevator motor is fully disposed of, just as is also the question of constant-speed motors.

A sample of the type of motor I have been discussing is on exhibition here, and while this motor was described at last year's convention, some of you may not fully understand it. We shall be glad to show it and explain its construction to any who are

interested. Quite a number of central-station men are here who have these equipments in service, and they can probably say something that will be more acceptable than anything I can say. Only one of the equipments installed to date, so far as I am aware, is not entirely satisfactory to the central station. This is a 10-hp equipment driving an elevator in a Chicago apartment house, several miles from the Chicago Edison Company's centre of distribution. The disturbance of the voltage on the circuit, according to Mr. Gear, of the Chicago Edison Company, is between two and three volts. He says that anywhere else in Chicago a disturbance of this amount would not affect their service in the least, but in this particular residence district they do not like to have even so small a variation. The equipment has not yet been taken out, and we can probably make certain refinements that will keep it there. Mechanically, the Chicago Edison Company has been entirely satisfied, as have been the apartment-house people. This particular motor replaced a 500-volt motor, going on the same bed-plate.

THE PRESIDENT: In connection with the offer of prizes by the Co-operative Electrical Development Association, your president, some little time ago, appointed Messrs. Burnett, Mather and Montague as a committee to judge the papers submitted in the contest. I will ask Mr. Burnett to make the report of that committee.

MR. DOUGLASS BURNETT (Baltimore, Md.): Your committee examined very carefully the twenty-two papers submitted, and was very much pleased to find that the individual ideas of the three members of the committee were entirely in harmony. It therefore offers the following unanimous report:

REPORT OF THE COMMITTEE ON AWARD OF PRIZES OFFERED BY THE CO-OPERATIVE DEVELOPMENT ASSOCIATION

The undersigned committee appointed by President Blood to judge papers on the subject of *Organization and Conduct of a New-Business Department Suitable for Central Stations in Cities of 50,000 Population and Under,* begs to report as follows:

First prize—M. S. Seelman, Jr., Brooklyn, N. Y.
Second prize—S. M. Kennedy, Los Angeles, Calif.
Third prize—J. M. Robb, Peoria, Ill.

Honorable mention: C. N. Jackson, Toledo, Ohio; Fred. D. Sampson, Charlotte, N. C.; W. R. Sweaney, Minneapolis, Minn.; James L. Wiltse, Brooklyn, N. Y.

We recommend that in lieu of any combination of these papers they be all published.

Respectfully submitted,

Committee, Douglass Burnett, Chairman,
Joseph E. Montague,
Eugene H. Mather.

The President: Gentlemen, you have heard the report of the committee. Mr. Crouse, with whom this idea originated, is here, and I am sure he will take pleasure in turning over the prizes to these gentlemen. First prize, $500; second prize, $300, and third prize, $200.

Mr. Crouse: Mr. President and Gentlemen—I want to say a few words before awarding these prizes. In the first place, we shall be glad to follow out the recommendations of your committee, and it will be our desire to give the papers that won the prizes and those that have had honorable mention the widest possible distribution.

During the coming year we have it in mind to offer other prizes for papers along commercial lines that may be comparable with papers that have been submitted here, and our only idea in asking the good offices of your president and this association in this connection was to give the matter a standing, so that when another prize of this character is offered every central-station manager or employee in the commercial department will have a reasonable degree of assurance that the funds are forthcoming. In any future work of this kind we may perhaps get a larger number of papers, and there may possibly be an improvement in the general quality. The manufacturers whom I have the honor to represent in connection with this offer, and whose good judgment in reference to the selling effect of a move of this kind is perhaps better than my own, have been unanimous in the belief that the $1000 spent on these prizes carried possibly a greater selling effect than any other $1000 ever spent by any manufacturer or group of manufacturers.

I believe these papers will represent to a marked degree

successful and progressive commercial practice, and by putting them into the hands of all the central stations we feel reasonably sure that advantage will accrue both to central stations and to the manufacturers, because there is a certain direct ratio between the demand for electrical apparatus and the use of electric current. Current must be used before the manufacturer can produce the utilities through which the current is served. I therefore take pleasure in handing to Mr. Seelman, in behalf of the manufacturers whom I represent, this New York draft for $500, and I return the other drafts to the president to hold for transmission to the winners of the second and third prizes. In conclusion, I hope the gentlemen will experience as much pleasure in spending the money as it affords the manufacturers to give it.

THE PRESIDENT: The president will take pleasure in telegraphing the results of the competition to the two gentlemen who are not here, and the drafts will be forwarded them.

MR. S. R. BRADLEY, JR. (New York City): I move that a committee of five be appointed by the president to consider and report to the executive committee upon the relations between this association and such local associations as may exist in the various states or districts.

(The motion was carried.)

THE PRESIDENT: I will appoint as the committee provided for in the motion just passed, the following gentlemen: S. R. Bradley, Jr., New York, N. Y.; Ernest H. Davis, Williamsport, Pa.; Leon H. Scherck, Birmingham, Ala.; John F. Gilchrist, Chicago, Ill.; W. H. Fellows, Leavenworth, Kan.

THE PRESIDENT: We will now take up the paper on *Modern Switchboard Practice, with Particular Reference to Automatic Devices*, by Mr. E. M. Hewlett, of Schenectady.

Mr. Hewlett presented the following paper:

MODERN SWITCHBOARD PRACTICE, WITH PARTICULAR REFERENCE TO AUTOMATIC DEVICES

In this paper only representative cases are dealt with, practice varying with individual installations according to the local conditions. It is, of course, understood that no absolute rules can be laid down to govern practice. Only one general principle would I put forward as a basis for laying out a system of control,

FIG. 1—100-AMPERE, 2500-VOLT, T. P. D. T., K-3 OIL SWITCH

viz., "Make everything just as simple as the operating conditions will economically allow."

Before discussing the application of automatic devices, a brief description of the different devices will be in order.

First. As to switches for alternating current (except in connection with series arc circuits and in the small plants, where plug switches may be used), oil switches are the only switches to be considered. Oil switches may be divided into three classes, according to rupturing capacity, namely, small, medi-

um and large. The small switches would usually be hand-operated and mounted directly on the back of panel, though under some conditions they may be placed a short distance from panel or may be even electrically operated, but for no other reason than economy or convenience.

The medium capacity switches are usually mounted away

FIG. 2—100-AMPERE, 2500-VOLT, T. P. D. T., K-3 OIL SWITCH

from the panel, either on framework or in cells, and would be either hand-operated or electrically operated, according to conditions of convenience or economy.

The large switches should always be away from panels, in masonry cells and electrically operated.

Figures 1 and 2 show a form of switch suitable for currents

up to 500 amperes and 4500 volts, having a rupturing capacity suitable for total three-phase generating capacity as follows:

Rating of Switch	2300-Volt Auto.	2300-Volt Non-Auto.	4500-Volt Auto.	4500-Volt Non-Auto.
100 and 200 amp.	2100-kw	5300-kw	1900-kw	4700-kw
300 and 500 amp.	2350-kw	5900-kw	2100-kw	5300-kw

This switch is designed single and double-throw, the double-throw being provided with two handles, interlocked, so that only

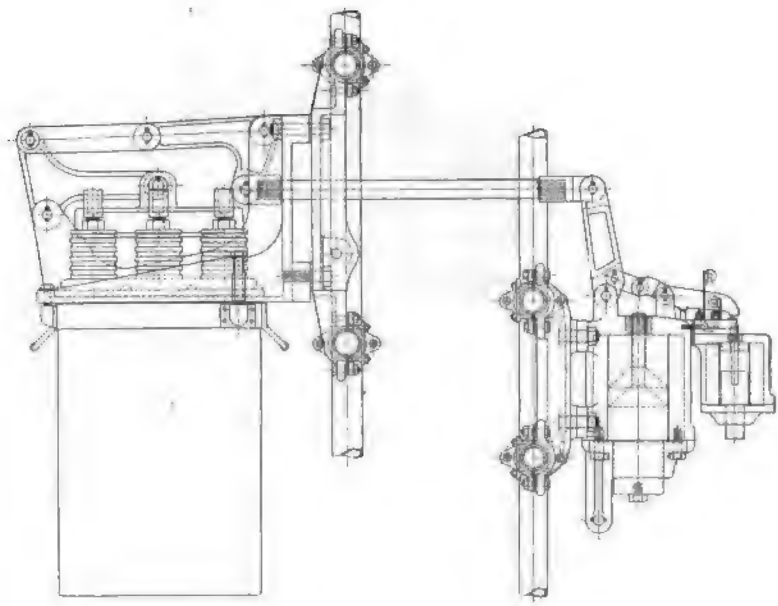


FIG. 3—K-2 OIL SWITCH OPERATED BY DIRECT-CURRENT SOLENOIDS

one throw can be closed at a time. Up to 300 amperes, 2500 volts, trip coils in series with the line may be provided. Above this, the trip coils are operated from current transformers.

Figures 3 and 4 show a form of switch that is good up to 1500 amperes, 2300 volts, and 300 amperes, 15,000 volts, and with rupturing capacity suitable for total three-phase generating capacity as follows:

	2300-Volt Auto.	2300-Volt Non-Auto.	13,000-Volt Auto.	13,000-Volt Non-Auto.
On panel	2350	59CO	1050	2600
In cell	2700	6800	1200	3000

This form is made only in single-throw.

Figures 5 and 6 show a form of switch that is good up to 800 amperes, 15,000 volts, with rupturing capacity suitable for total three-phase generator capacity as follows:

	2300-Volt		13,000-Volt	
	Auto.	Non-Auto.	Auto.	Non-Auto.
On panel	4800	12,000	3000	7500
In cell	5500	13,800	3450	8650

Any one of these switches may be mounted on the back of

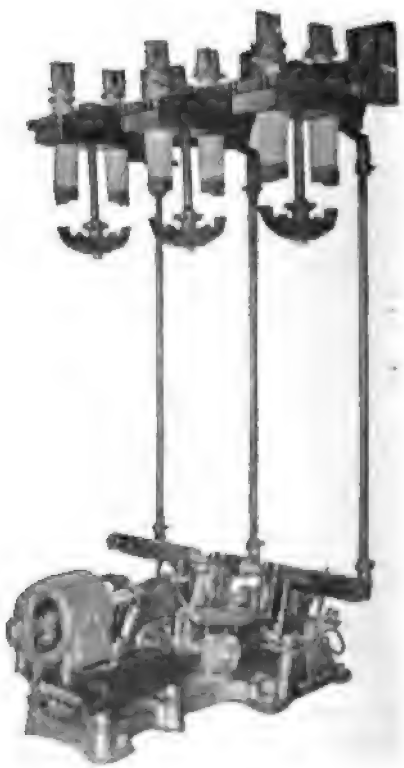


FIG. 4—MOTOR-OPERATED T. P., 1500-AMPERE OIL SWITCH

panels, on framework, or in cells, or may be operated electrically either by means of solenoid or motor mechanism.

In all of these forms of switches the design consists of a frame containing the contacts, studs and their insulators, a removable

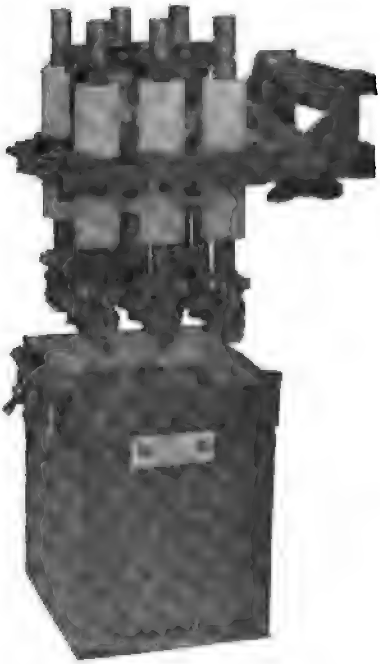


Fig. 5—800-Ampere, 13,000-Volt, T. P. S. T., Type F, Form K-4 Oil Switch

Fig. 6—300-Ampere, 15,000-Volt, S. P. S. T., Type F, Form K-4 Oil Switch

oil vessel suspended from the frame, and a movable contact bar which, in closing, is drawn up to bridge the contacts.

Figures 7, 8 and 9 show the latest type of oil switch now so generally used in the largest power stations.

The switch is provided with a positive locking device con-

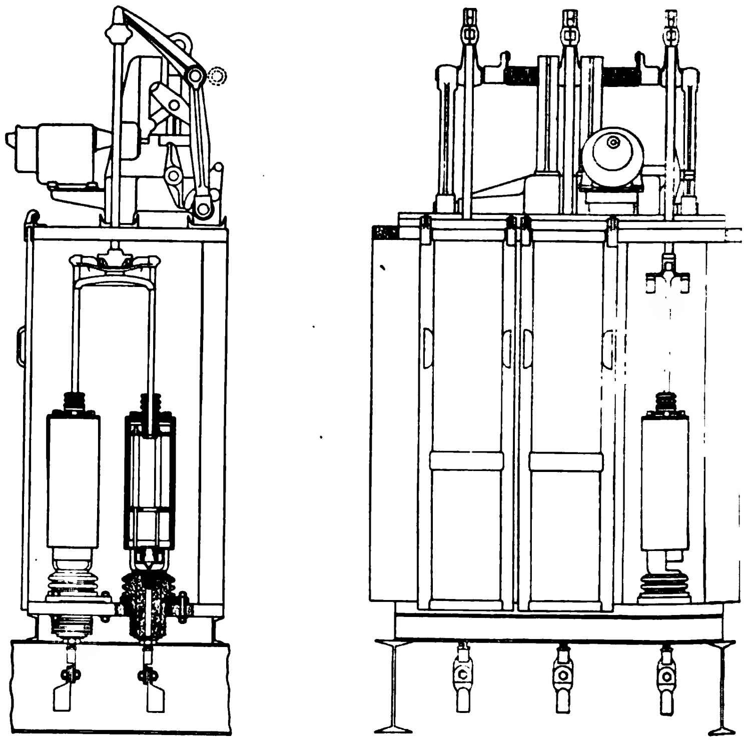


FIG. 7—TYPE F, FORM H-3 OIL SWITCH

sisting of a latch which prevents it from closing or opening until the latch has been removed by the tripping magnet. The first part of the movement of the tripping magnet releases the latch, allowing the switch to operate, and the further movement closes the contact in the motor circuit, the motor completing the stroke and resetting the mechanism for the next operation.

There have been various criticisms in the past regarding "pumping" of oil switches of this general class. These related to an earlier form which has no positive lock. This past trouble has resulted from failure to adjust the switches properly, the

FIG. 8—TOP MECHANISM FOR TYPE F, FORM H-3 OIL SWITCH

adjustment consisting in setting the crank the proper distance back of centre.

Satisfactory progress is now being made toward standardizing drawn-steel oil vessels, which give considerable increase in strength to withstand the shock of opening severe short-circuits, and, being of one piece, make absolutely oil-tight vessels.

Relays

The more important types of relays now in use are:

(1) Overload for alternating current circuits	Instantaneous Definite time limit Inverse time limit
(2) Reverse current for alternating current circuits With voltage winding	Instantaneous Definite time limit Inverse time limit
(3) Reverse phase for alternating-current circuits	
(4) Reverse current for direct-current circuits	Instantaneous Inverse time limit

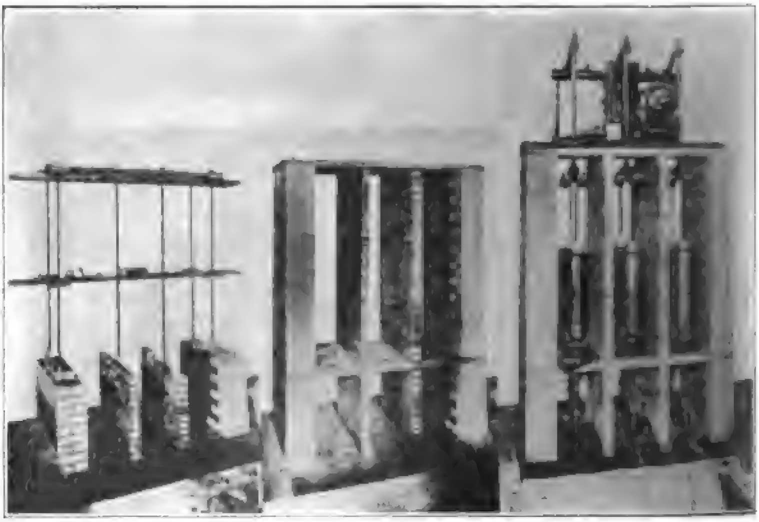


FIG. 9—TYPE F, FORM H-3 OIL SWITCH, 1200 AMPERES, 13,000 VOLTS, T. P. S. T., SHOWING CONSTRUCTION OF SPECIAL CELL, USING STANDARD LITHOLITE BRICK BARRIERS

(1) Instantaneous overload relays are so well known that little comment need be made regarding them. Many improvements have recently been made, however, in the calibrating devices. The improved device does not require clearance space below the relay for a screw-driver, which is necessary with the former device. The indicator on the calibrating tube is much clearer and can be easily read from a distance. A positive lock

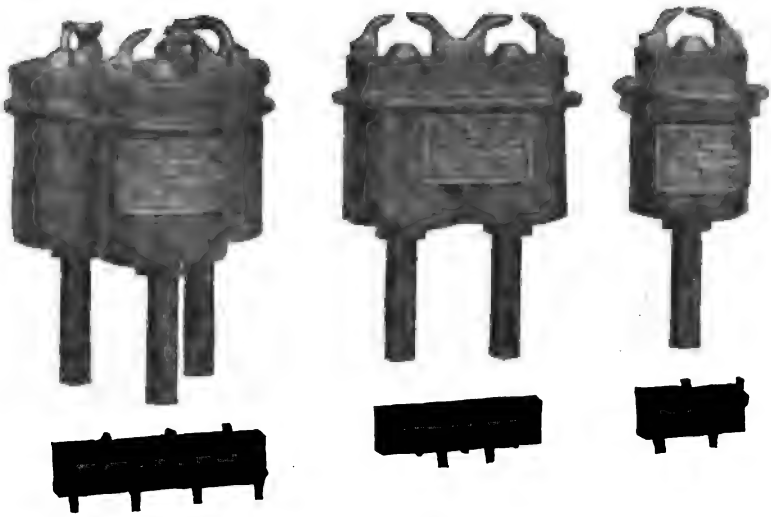


Fig. 10—Instantaneous Overload Relays, Type D, Form B

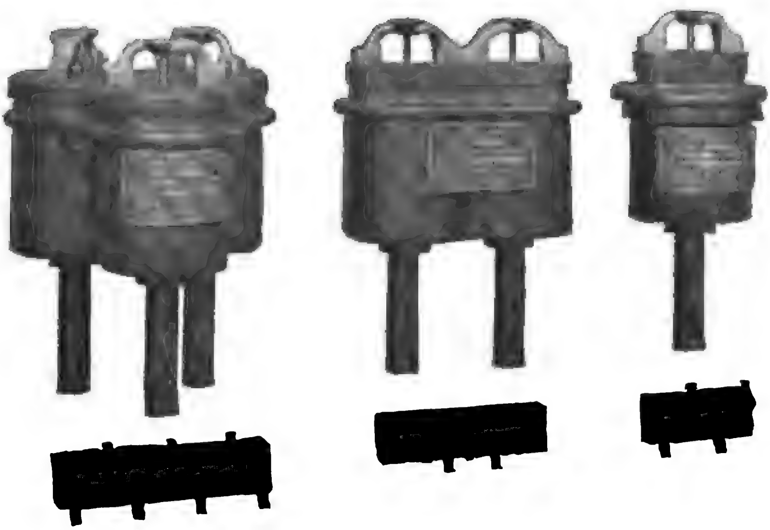


Fig. 11—Instantaneous Overload Relays, Type D, Form B-2

is also provided, which prevents accidental change of calibration. The contacts and connections from the windings to the contact have been improved, also the insulation of the various parts of the relay.

Figure 10 shows standard contact-closing instantaneous overload alternating-current relays and Figure 11 shows the relays arranged for contact-breaking.

FIG. 12—TIME-LIMIT RELAY, TYPE P, FORM C-1

Figures 12, 13 and 14 show the "bellows" type time-limit relay. The improvements spoken of in connection with the instantaneous relay are also embodied in the latest time-limit relays. The bellows timing feature of the relay has been retained on account of its satisfactory operation, many favorable reports having been received regarding its operation.

Figure 15 shows the inverse time characteristic curve of a

relay taken at random from stock. This curve is taken at 60 cycles only, but the calibration remains substantially the same for all commercial frequencies.

The inverse time element makes this form of relay selective under many conditions, so that a circuit in trouble will be opened without shutting down other circuits.

In some cases, however, an inverse time-limit relay is not

FIG. 13—TIME-LIMIT OVERLOAD RELAY, TYPE P, FORM C-2

desired, but a relay with a definite time limit is more suitable. In this case the bellows relay is adapted for the work by the addition of spring acting between the plunger and the diaphragm. When a short-circuit occurs the plunger is drawn up, the spring in turn forcing up the diaphragm and closing the relay contact.

Alternating-current *reverse-current* relays can be made to

operate on reversal of energy under *certain conditions*, either instantaneously or after a predetermined interval. Mechanically, the construction is identical with the overload relays described above. Electrically, the relay consists of two windings respectively in series with and in shunt to the line. These windings

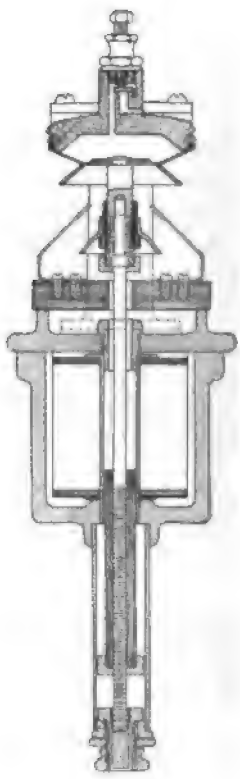


FIG. 14—TIME-LIMIT OVERLOAD RELAY

normally oppose each other, but on reversal of energy they assist each other and operate the relay.

An alternating-current reverse relay being dependent for operation upon potential supplied from the line, it is evident that conditions will arise at the time of severe short-circuits, when the

potential will drop to a very low value, in which case the relay will lose its reverse feature and operate as an overload relay

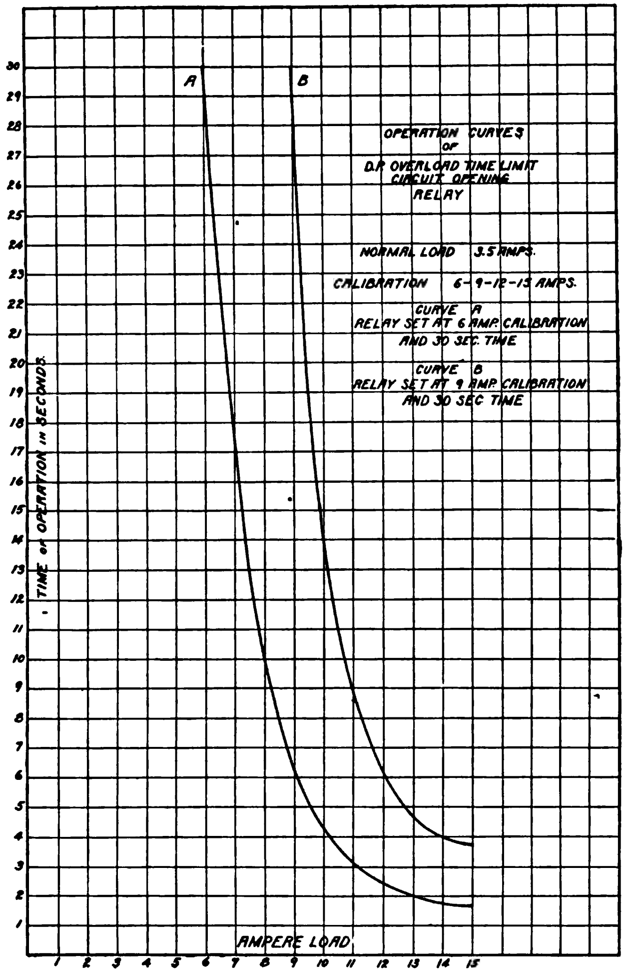


FIG. 15—OPERATION CURVES OF OVERLOAD TIME-LIMIT CIRCUIT-OPENING RELAY

with a high setting. No damage would result from this, but all the reverse relays on the circuits in parallel would operate, caus-

ing a shut-down. For this reason an alternating-current reverse-current relay dependent on current and voltage for its action and operation is not reliable under short-circuit conditions. The inverse time-limit relay heretofore mentioned will give more satisfactory results.

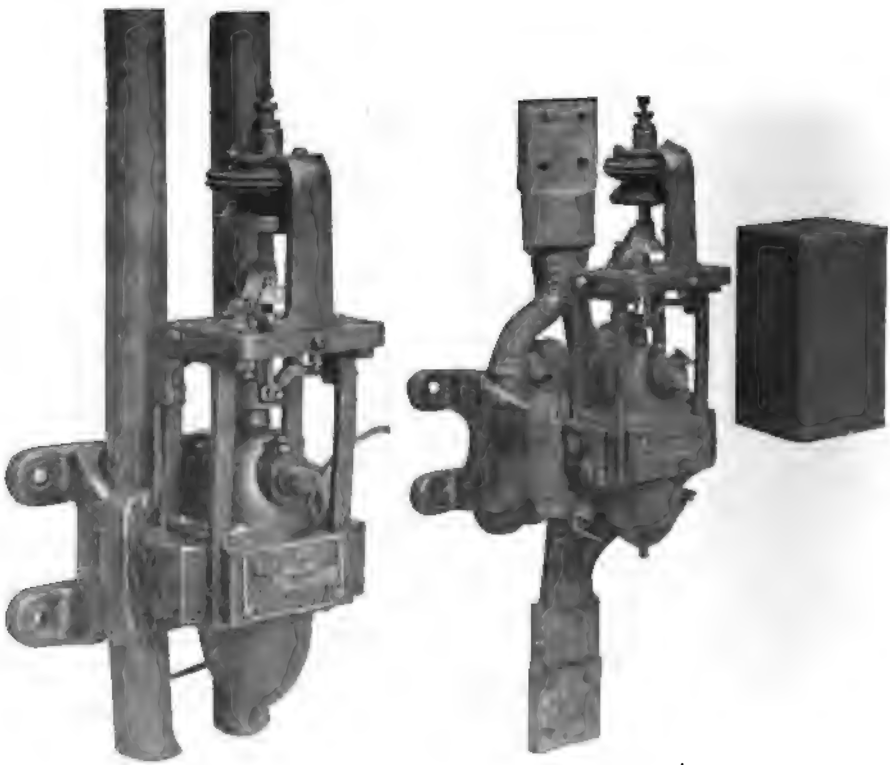


Fig. 16—Direct-Current Reverse-Current Time-Limit Relay, Type R, Form G, 1000-4000 Amperes, 125-500 Volts, 500-Ampere Reverse

Fig. 17—Type R, Form C-2, 1000 Amperes, 500 Volts, Direct-Current Reverse-Current Time-Limit Relay

Reverse-phase alternating-current relays, which are a comparatively recent development, are designed to trip a circuit-breaker in case the leads of the circuit become interchanged, which sometimes happens when making changes or repairs.

These relays are useful for the protection of elevator motors or in any case where change of phase rotation is objectionable.

Reverse-current relays for direct-current circuits are made either of the instantaneous or time-limit types. The instantaneous type consists of a soft-steel horseshoe magnet and an armature pivoted between the poles of the magnet and wound with a

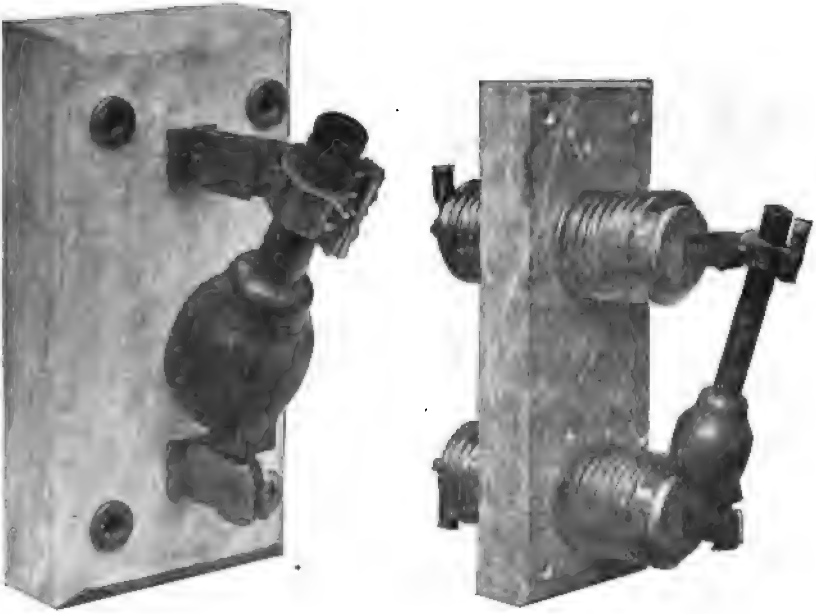


Fig. 18—Expulsion Fuse, Type T, Form D, 2300 Volts, 100 Amperes

Fig. 19—Type T, Form D, Expulsion Fuse Holders, 6600 Volts, 30 Amperes

shunt winding. The magnet is designed to be mounted upon a current-carrying stud of a circuit-breaker, from which it derives its excitation. The relay will operate only on reversal of current.

Figures 16 and 17 show the time-limit relay, which is essentially the same as the instantaneous relay with the addition of the time-limiting device, and with the exception that it is designed for mounting on feeder cables instead of on the stud

of a circuit-breaker. The time-limiting device is a modification of bellows arrangement used on alternating-current relays previously described.

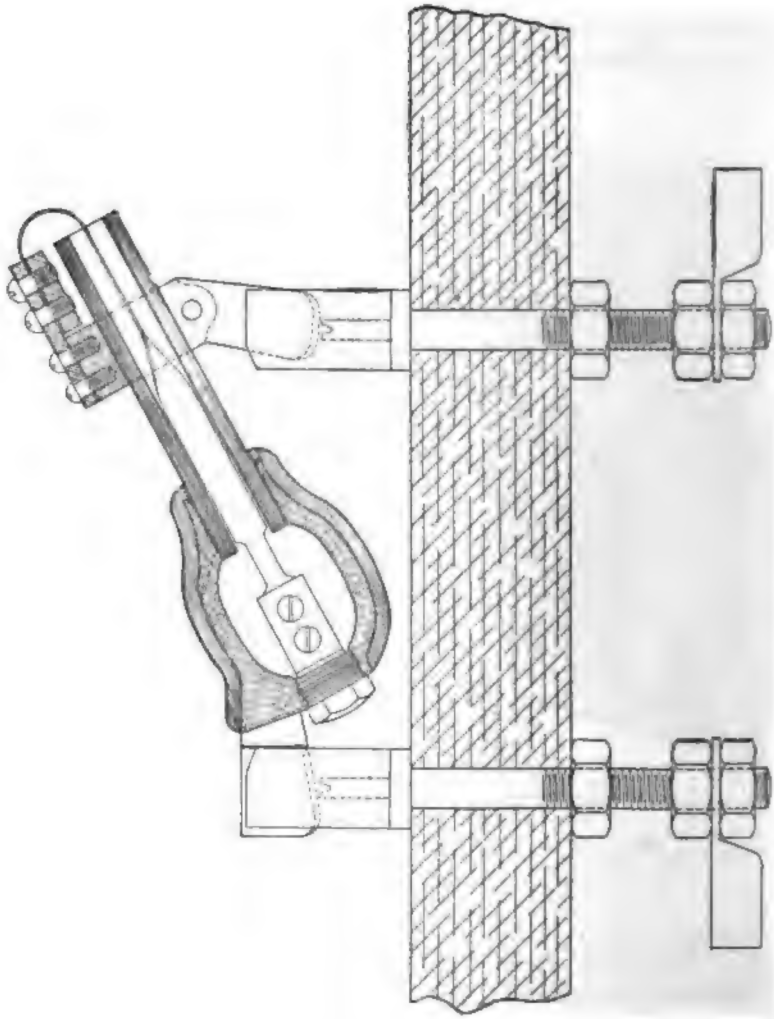


Fig. 20—2300-Volt, T. D. Expulsion Fuse Holder

These relays are made to encircle one cable or two or more in multiple, and if the cable and corresponding current are small,

a few turns of the cable around the magnet produces the proper excitation.

You are probably familiar with the expulsion type of fuse block known as the type "T," form "D" (see Figures 18, 19 and 20).

This block consists of a metal expansion chamber into the end of which is screwed a fibre tube. The fuse is carried through the tube into the chamber, where it is of smaller cross-

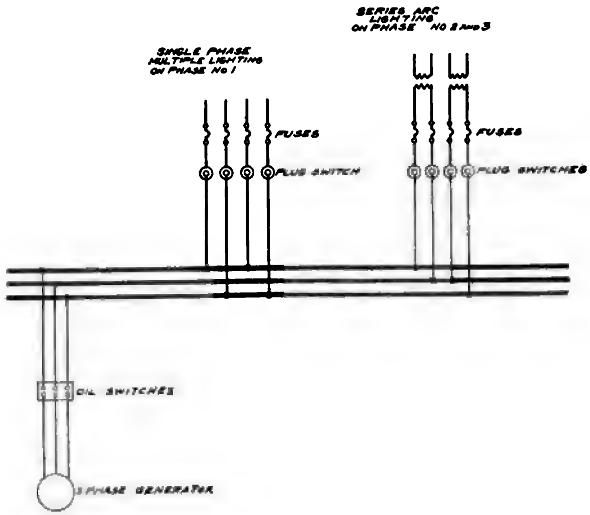


Fig. 21—T. D. Expulsion Fuse Holder for Potential Fuses
Fig. 22—Case No. 1—Small Plant, 60 Cycles, 2300 Volts

section to insure the blowing of the fuse in the chamber instead of in the tube. These fuse blocks have been used extensively for 2300 volts, up to 200 amperes, and have been designed for heavier current and higher voltages, 400 amperes at 2300 volts, and also for 50 and 100 amperes up to 30,000 volts. They have also been developed in a smaller form for use as a fuse for protection of potential transformers (see Figure 21), to replace the glass tube fuses. The rupturing capacity of the "TD" fuse is

high, the limit to its possibilities being its mechanical strength. For this reason it can be used in some cases where automatic

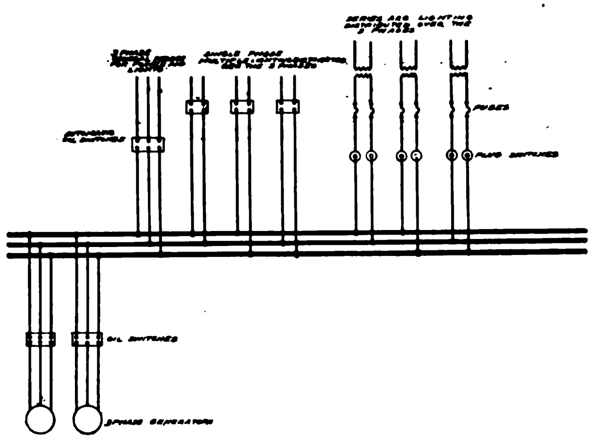


FIG. 23—CASE NO. 2—MEDIUM-SIZE PLANT, 60 CYCLES, 2300 VOLTS

switches might otherwise be required, but these cases are confined to instances where the delay of replacing fuse is per-

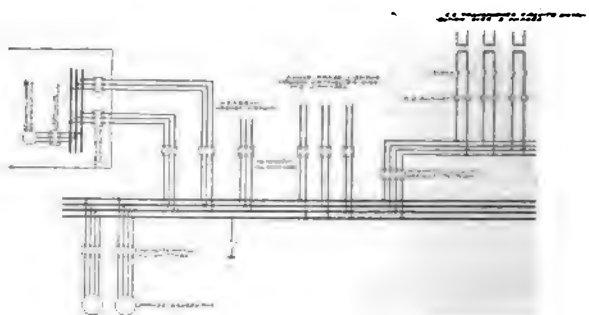


FIG. 24—CASE NO. 3—LARGE PLANT, 4-WIRE, 3-PHASE, 60 CYCLES, 4500-2300 VOLTS

missible. They should always have disconnecting switches when so used, or be used in series with non-automatic oil switches.

It has been found in test that when the fuse blows, the cir-

cuit is ruptured at the zero point of the wave, which is a most important feature.

In this discussion four representative systems will be considered, as follows:

Case No. 1—For villages and small cities, with a simple 2300-volt, 60-cycle distribution (Figure 22).

Case No. 2—For medium-size cities, with 2300-volt, 60-cycle distribution (Figure 23).

Case No. 3—For large cities, with 4150-2300-volt, 60-cycle, 4-wire, 3-phase distribution (Figure 24).

Case No. 4—For very large cities, with 6600 to 13,200-volt, 25 to 60-cycle, underground transmission to substations and direct-current or alternating-current distribution from the substations (Figure 25).

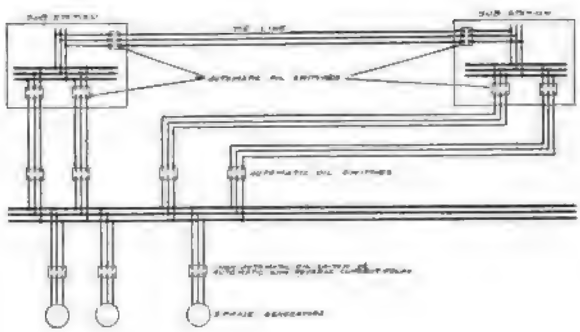


FIG. 25—CASE NO. 4—LARGE CENTRAL STATION, 25 CYCLES, 6000-13,000 VOLTS, FEEDING A NUMBER OF SUBSTATIONS

Under the different cases, we have to consider the different circuits separately. For instance, if two circuits from the same system feed different classes of service it may be advisable to treat each circuit differently as to automatic protection.

Under case No. 1 we have the simplest conditions, which could be well met by the use of plug switches and fuses. The new type of fuse block already described, known as the "TD," is suitable for such work. Automatic oil switches could also be used on the multiple feeder circuits in place of plug switches

and fuses. Instantaneous trip coils would be used, as the extra cost of time-limit relays would not be warranted. The generators are not ordinarily provided with automatic protection.

Case No. 2 represents a large number of systems with slight modification. The diagram shows one set of 'bus-bars, but if there were a considerable number of feeder circuits that had to be kept alive twenty-four hours in a day, or if there were two classes of service that should be kept independent, two sets of 'bus-bars would be advisable.

Under this case overhead lines would probably be used for the circuit, though in some cities there may be a partial underground distribution.

Fuses could be used satisfactorily on systems under this *case,* but automatic switches allow the circuit to be cut in more quickly and would generally be recommended except on the smaller plants. Under any conditions fuses would be used for protecting the series arc transformers.

Where automatic switches are used on the smaller plants they should have instantaneous trip; in the larger plants inverse time-limit relays would be advisable.

The generator switches would be non-automatic, it being found in practice that more inconvenience arises from automatic protection than from non-automatic switches.

In a plant of say 1500 kilowatts and above it is good practice to mount the oil switches away from the board, operating the switches by means of suitable levers and cranks.

When the station capacity reaches 3000 or 4000 kilowatts it is advisable to place the switches in masonry compartments and in some cases operate the switches electrically.

Under case No. 3 there may be various modifications, but I have chosen a system with a main generating station at the outskirts of the city with an alternating-current-direct-current substation in the business district (see Figure 26). In a system of this character, automatic oil switches are invariably used on the outgoing circuits and inverse time-limit relays are recommended except for the substation feeders, which should have definite time relays. If automatic switches are provided with the generators a reverse-current definite time-limit relay is probably the best form of protection. A better arrangement would be, however,

to omit the trip coils from the switches and let the relay simply light a lamp or ring a bell.

The incoming lines at the substation should have inverse time relays. This, in combination with the definite time relays in the main station, in case of a short-circuit between stations would open up both of the line switches at the substation and the switch of the short-circuited feeder only in the main station, thereby indicating which feeder was in trouble.

On a severe short-circuit the synchronous machines in the substation would possibly feed back into the short-circuited line before the machine switches could open and cause more current to flow in the short-circuited line than in the other line from the main station. On account of the inverse time element of the line relays, the relay in the short-circuited line would operate more quickly than the relay in the other line, relieving the system. As the relays in the synchronous machines are preferably of the instantaneous type, the above case would not often arise. If three lines were installed from main to substation, the inverse time relays would act selectively on short circuit and only the short-circuited line switches would open.

On the direct-current side of the rotary converters or motor generator sets reverse-current relays are usually provided to trip the circuit-breaker of the machine in trouble, leaving the other machines in circuit.

Case No. 4 represents the largest central stations feeding a number of substations, all distribution to consumers being from the substations, such distribution being either direct or alternating-current and sometimes both (see Figures 26 and 27).

The voltage of this class of systems is from 6600 to 13,000 volts, and the amount of energy generated is large, making it necessary to use electrically-controlled switches, mounting the switches and 'bus-bars in masonry compartments. The usual practice is to provide two sets of 'bus-bars, each set being sectionalized at least once. In some cases the machines are all run in parallel on one set of 'bus-bars, using the second set only for emergency. In other cases some of the generators and feeders are connected to one set and others to the other set. It is obvious that while the best load factor and efficiency may not be obtained, liability to a complete shut-down is eliminated by the latter method, and in case of a short-circuit there is not so much energy

feeding in parallel and consequently less trouble is likely to arise. To illustrate the amount of energy developed on short-circuit with a number of large generators in parallel, both in test and

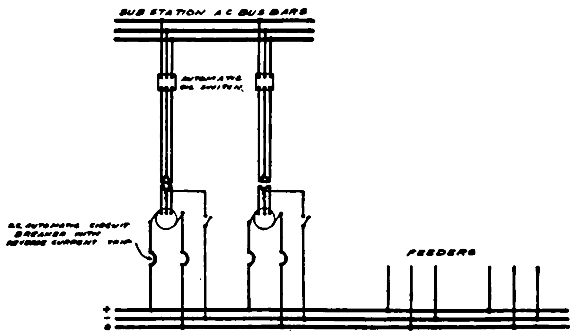


FIG. 26—ALTERNATING-CURRENT DIRECT-CURRENT SUBSTATION

in practice, heavy knife disconnecting switches have been forced open and cables have been moved out of place, due to the mag-

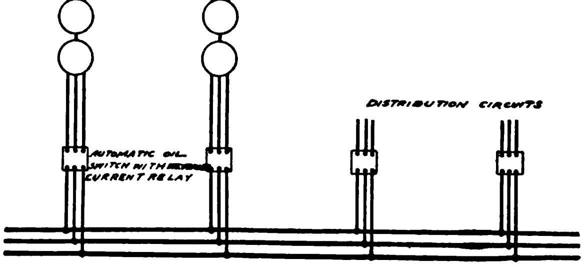


FIG. 27—FREQUENCY-CHANGING SUBSTATION

netic repulsion between the parts caused by the momentary heavy current.

As to automatic protection, practice varies somewhat. Either

non-automatic switches or automatic switches with reverse-current time-limit relays are used on the generators. On feeders, the bellows type inverse time-limit relay has been used largely with excellent results.

In a system with three or more circuits to each substation, or with only two to each substation, if tie lines are used between stations, selective action can be obtained by the exclusive use of inverse time-limit relays properly adjusted, or with inverse time-limit relays on the substation end of lines and definite time-limit relays on the generating station end.

With three lines feeding a substation, direct from generating station or partly through another substation, a short-circuit on one line causes the other two lines to feed in multiple into the short-circuited line, giving the latter twice as much current as either of the other lines. The relay of the short-circuited line would operate more quickly than the other relays, opening the circuit and relieving system. (In an extreme case of short-circuit it is possible that all the relays in the substation may operate, due to the very heavy rush of current, which might eliminate the time feature on the relay.) The relays at the generating station end, if either of definite time-limit type or if of the inverse type and set for a longer time than the substation relays, will not operate until after the substation relay, and then only the relay of the line in trouble will operate. Especially in the case of a system with considerable synchronous apparatus, the matter of the setting of the relays should be carefully studied and experiments made to determine the proper adjustment.

The generating end of the substation should be treated the same as generating stations under cases Nos. 2 and 3 if alternating current, or if direct current the same as substations discussed under case No. 3.

As already stated, each case must be considered separately, no two systems being operated under the same conditions, and experience will show better than anything else the proper method of protection.

I wish finally to emphasize the necessity of employing a first-class station attendant, and more important is the point of simplicity of layout, with special reference to avoiding complication by automatic protective devices. It is much safer and more satisfactory to depend on a good man keeping up the

system, various apparatus, and so forth, thereby thoroughly posting him and consequently making it much safer to depend upon him than it is to depend on automatic features on various apparatus. The introduction of too much automatic apparatus, which is inherently necessarily complicated, therefore liable to get out of order, should be avoided. The more automatic features there are in a station the more there will be to take care of.

DISCUSSION

MR. WALLAU: There are a couple of points I noted in connection with the paper. Mr. Hewlett recommended for feeder switches the use of time-limit relays, and while I think this may hold good on large feeders carrying a great amount of energy, I think that small distributing feeders, carrying anywhere from 100 to 300 kilowatts, an automatic switch controlled by an instantaneous relay, set high enough so that ordinary variations in load—which are liable to come on and are only instantaneous—will not trip it, is just as good protection. For instance, in operating a number of lighting circuits our average load was around 50 amperes—reaching, perhaps, 65 to 75 maximum—and instantaneous relays were set to open the switch with 90 amperes in the wire; we have experienced no difficulty in opening the circuits under these conditions, and they do not open at times when they should not. In connection with relays, of which very little has been said here, there are some illustrations showing triple-pole, closed-circuit relays, known as the time-limit overload relay, shown on page 495, type P, form C-2, and the instantaneous type, Figure 11, on page 493. In regard to this type of relay, we have some of them in operation, and we have found considerable difficulty with the time limit. There seems to be a sticking action there that makes them practically instantaneous. Another thing that we have found is that the scheme of connection that was sent us—of which I think we got six different copies, no two of which were alike—we could not make operate. When we used them in a Y-connected three-phase feeder, having the neutral grounded, the connections for the relay were such that if any one leg operated the relay passed the current through a three-wire trip coil, one-half of which was supplied with current from the overloaded current transformer and the other half

was short-circuited through the relay contacts on the other two phases of the relay, and the result was there was not magnetism enough to raise the plunger, and surely not enough to trip the switch. We had to discard the use of a three-wire coil and use a two-wire coil with a somewhat different connection. I think this is a thing that is liable to give considerable trouble if it is not known. Had we depended merely upon the reliability of the diagram and not made tests for ourselves, we might possibly have had considerable trouble from the fact that a ground would not have opened the switch when we expected.

MR. HEWLETT: This particular type of relay is the open-circuiting type, and is used in connection with current transformers. The relay contact must be so made as to shunt the trip coil normally, and when relay acts to cut the trip coil in series on the current transformer. This is a rather difficult thing to do, and is not advisable if it is possible to secure a source of constant potential to operate the trip coil and use the close-circuiting type of relay.

THE PRESIDENT: We will now take up the paper on *Control of Motors on Electric Light and Power Circuits,* by Mr. H. D. James, of Pittsburgh

The following paper was presented by Mr. James:

CONTROL OF MOTORS ON ELECTRIC LIGHT AND POWER CIRCUITS

Many admirable papers have been written describing in detail the operation of the various standard motors, giving their characteristics, curves, and in general, the method of control. Recently, papers on this subject have appeared by Mr. C. F. Scott in the April and May numbers of the *Engineering Magazine,* and by Mr. Wm. E. Reed in October, 1905, issue of the Transactions of the Engineers' Society of Western Pennsylvania.

It is the intention of this paper to treat of the control problems only, and the writer assumes that the general characteristics of the different motors are familiar to you.

To assist in understanding the general methods of control, the following table has been prepared, dividing the control of motors into general classes and again into subdivisions. In a number of cases these divisions have had to be assumed arbitrarily and are intended only for convenience in following this paper:

GENERAL CLASSIFICATION OF CONTROL SYSTEMS

Rheostatic	Direct current	Resistance in series with the armature.
		Resistance in both series and parallel with the armature.
	Alternating current	Resistance in series with the primary.
		Resistance in series with the secondary.
Voltage	Direct current	Changing voltage at motor terminals.
		Series—Parallel.
		Using several lines of different voltages.
	Alternating current	Changing impressed voltage by transformers.
		Series—Parallel.
Changing Motor Characteristics	Direct current	Changing field strength.
		Changing number of armature conductors in series.
		Changing the number of poles.
	Alternating current	Changing the number of poles.
		Changing the frequency (cascade connection).
Mechanical Devices		The use of gearing, clutches, *et cætera.*
		Using two or more motors geared for different speeds.
		Varying the amount of iron in the field poles.
		Varying the air gap between the armature and field.
Braking	Mechanical	Brake released by a magnet.
	Electrical	Brake obtained by operating the motor as a generator.

RHEOSTATIC CONTROL—DIRECT CURRENT

The oldest and perhaps best known method of control consists in reducing the voltage at the motor terminals by means of resistance in series with the armature. This method of control is embodied in all direct-current starting devices, from the small face plate to the heaviest unit switch device.

Face Plate and Unit Switch Starters

Face plate starting devices are generally built in but one form consisting of an arm passing over a series of contacts which gradually short-circuits sections of the resistance until the arm reaches the last position in which all of the resistance is short-circuited. The arm is held in this position by means of a magnet connected across the line, sometimes in series with the shunt field of the motor. This magnet releases the arm should the voltage on the system fail and the spring returns the arm to the off position. This is a very convenient arrangement, but one which is not embodied in commercial controllers, other than the above type, until we reach the large controllers consisting of electrically-operated switches, or the large hand starters which have a no-voltage coil for tripping the circuit-breakers when the line voltage fails. At various times controllers have been built in which the drum is returned to the off position when tripped by the release of a shunt coil, but they have not come into general use. Also a type of controller has been built and placed on the market which is a combination of the drum switch having an electrically-operated switch used in connection with same.

In general, however, the drum and face plate controllers used for intermittent service do not embody such a device.

Regulating Controllers

Rheostatic controllers for regulating purposes are generally used in connection with series or compound-wound motors. The torque of a series motor varies approximately as the square of the current, therefore a wide range of speed regulation can be obtained by varying the current through a comparatively small range. In most cases this variation in current does not exceed 40 to 50 per cent. With a compound-wound motor more range of current value is required. The torque of the shunt motor

varies directly with the current, so that this motor is not well suited for rheostatic control. This form of control is used extensively for cranes, hoists, bending rolls and intermittent service of this character. The two forms of mechanical controllers are used.

The drum type of controller has a rotary motion of the handle and separately mounted resistance. This controller can be readily enclosed and is compact in construction, but the rotary motion of the handle is sometimes objectionable.

The disc type of controller consists of either a face plate or grind-stone, upon which a series of contacts are fastened. The brush holders are moved over these contacts by the reciprocating motion of the controller handle. These controllers, being flat in construction, can readily have the resistance mounted in the same frame as the switching mechanism. They can also be operated at a distance by means of a bell crank and levers. For this reason they are used extensively for cranes and in other places where it is not desirable to have the controller located in front of the operator, the reciprocating motion of the handle being similar to the motion of an engine lever. This motion of the controller handle is very convenient when a motor is substituted for a steam engine. If the resistance is mounted with the controller it is not so convenient to protect the same from the weather, but in most cases the controllers can be placed under cover.

Automatic Controllers

The dash-pot type of controller is perhaps the oldest form which is automatic in its operation. The arm which cuts out the resistance passes over a series of contacts under the tension of a spring or weight, the motion being retarded by a dash-pot. This control has been successful for small capacities.

For larger capacities an automatic control has been developed, consisting of a series of electrically-operated switches. These switches are actuated by means of a master switch and the rate of cutting out resistance can be made automatic by using some function of the counter e.m.f. of the motor, or the value of the current in the armature circuit. Such controllers are very durable, as a powerful magnetic blow-out can be used and the opening and closing of the switches is performed quickly by means of a mag-

net. Arcing tips can be provided which are readily renewable. The switches can be made interchangeable, so that repair parts for only one switch need be carried in stock. The switches can be mounted in any convenient manner best suited to the particular application. This form of controller can be readily designed to meet any reasonable starting condition. Recent developments have reduced the cost and complication of this type of controller and materially increased its durability.

With a controller of this type the current taken at the time of acceleration can be limited to any desired amount and the full value of this current will always be available, thus giving the maximum acceleration without injury to the motor. If the motor is suddenly reversed the automatic feature will prevent the resistance from being cut out of the armature circuit until the current has decreased to a predetermined value. In this way the "plugging" of a motor is automatically limited.

The unit switch type of control is well adapted for automatically starting pumps, air compressors, elevators, *et cætera.* It is used for printing presses, mill tables, cranes, ore bridges, car dumpers and many special purposes. It is particularly adapted to cases where the operating conditions are very severe.

This form of control has recently been subjected to a very severe test, as follows:

The controller was connected to a motor which operates a planer and the master switch was attached to the planer in such a way that the controller reversed the motor at the end of each stroke of the planer. The controller was so arranged that the speed of the motor could be adjusted on the cutting stroke by means of a field rheostat, but the motor always returned at the maximum speed, which in this case was four times the minimum cutting speed. The controller has been in continuous operation since December 1, and is often called upon to reverse the motor from five to six times a minute. Thus far all contacts are in first-class condition and it is probable that no renewals will be necessary for another year.

A larger type of switch was subjected to a braking test, as follows:

The switch was connected across a 500-volt direct-current circuit in series with two 100-hp railway-type motors and sufficient

resistance to reduce the current to 400 amperes. The operating coil of the switch was connected to a small switch operated by clock-work. This clock-work mechanism caused the main contacts to be opened and closed quite rapidly. The switch opened the circuit under the above conditions one hundred thousand times without materially reducing the arcing tips. The two motors in series with the switch produced a very severe inductive kick which made the arc over twice as large as the arc produced with only resistance in circuit.

The above tests indicate in a general way what may be expected from this type of controller.

Series and Parallel Resistance

Resistance in series and also parallel with the motor armature has sometimes been used to reduce the speed of the motor for printing-press work. The resistance in parallel with the armature gives a certain fixed current value through the series resistance which causes a definite drop independent of the load on the armature of the motor, which in turn gives a more stable running condition, although the efficiency is materially reduced.

ALTERNATING-CURRENT

Commutator-Type Series Motors

Resistance is used in series with the single-phase commutator type motor in the same manner as with the direct-current motor. The control is practically the same, although the amount of series resistance is affected by the power factor of the motor. This form of motor, as described in Mr. Renshaw's paper before your association last year, is well adapted for crane and hoist purposes. It has practically the same characteristics as the direct-current series motor and the control is effected in the same manner.

Induction Motors, Slip-Ring Type

The alternating-current induction motor of the slip-ring type is controlled by inserting resistance in the secondary circuit. The speed regulation is the same as that of a direct-current shunt motor, the reduction in the speed being directly proportioned to the amount of energy absorbed in the resistance, the torque in each case being proportional to the current. The speed of

the motor is different for different loads with the same amount of resistance. This form of motor has been applied extensively to cranes, mine hoists, elevators, gold dredges, pumps and similar apparatus.

This method of control is also used for starting polyphase induction motors. It is particularly well adapted for starting heavy loads, the current being directly proportional to the torque required.

The maximum torque which this motor can exert can be obtained at the moment of starting by properly proportioning the secondary resistance. This torque is usually from two to three times as great as the full-load torque of the motor and requires a proportionate increase in the current.

When used for starting purposes only, the control corresponds exactly with the direct-current starter, except that no automatic release has been provided when the current fails in the circuit. Such an automatic release is not necessary, as the self-induction of the motor limits the amount of current that will flow should power again be applied to the line, and there is no commutator which could be injured as with the direct-current motor. The overload current flowing at such time would open the circuit-breakers and relieve the motor immediately. In special cases where such a device is required a no-load circuit-breaker is used.

Recently a starting device for this type of motor has been developed which is connected to the secondary of the motor only, the primary of the motor being controlled by any commercial form of switch or circuit-breaker. This enables the starting device to be placed external to the motor at any convenient place, and by winding the secondary of the motor for low voltage and grounding the centre of the resistance, the operator is in no danger from shock. This starting device is entirely enclosed and dustproof, so that it can be located in cotton mills, powder factories, dyeing houses, ash-pits, and many places where external conditions will prevent the use of an ordinary starting device.

By using a line switch to open the primary of the motor in stopping, the arcing is localized in the switch where inspection and repairs are easily made. A line of controllers connected to

the secondary of the motor only can also be obtained. The resistance for such controllers is separately mounted.

Automatic controllers of the unit switch type are not available for this form of motors, except those operated by direct current or compressed air. A number of controllers for elevator work and similar purposes have been built by operating the magnets with direct current obtained from a small motor-generator set or other source of power. Recently controllers have been developed for larger motors of this type, employing compressed air for operating the switches. These controllers can be operated from the master switch and are applicable to hoists, conveying machinery and similar apparatus. Both the motor and the controller can be entirely enclosed where desired to protect the same both from dirt and from the weather.

Some very large unit switch controllers operated by direct current will be used employing oil-immersed switches for high voltages. The ability to use high voltage and a correspondingly small current is a decided advantage in designing controllers for alternating-current motors.

VOLTAGE CONTROL—DIRECT CURRENT

Motor Generator System

The system generally known as the Ward-Leonard system consists of a direct-current generator connected to a separately excited direct-current shunt motor. The voltage at the terminals of the motor is changed and reversed by changing the field current of the generator. A constant speed is obtained on every notch of the controller and as many speeds can be provided for as necessary. This form of control is well adapted for variable-speed work, also for reversing motors. Its application in the past has been limited, owing to the extra cost of the generator and its prime mover, whether a motor or an engine. Now, however, direct-current motors of very large sizes are being contemplated and in a number of instances have actually been installed at various places in Europe. To switch the armature current, which amounts in some cases to several thousand amperes, would cause prohibitive wear on the controller, but by use of this system of control only the field current of the generator is switched and the wear on the contacts has been reduced to a minimum.

Another advantage in using a separate generator for each motor is that a flywheel can be mounted on the shaft of the motor-generator set, and by varying the slip of the induction motor, or the field strength of the direct-current motor, this flywheel can be made to take the peak of the load so that a practically constant load is taken from the transmission circuit. This arrangement is known as the Ilgner System and has been installed in a number of places in Europe. A system similar to this is practically necessary where motors of hundreds and sometimes thousands of horse-power are used.

Series-Parallel Control

The series-parallel control system has been fully described in connection with railway work. It requires the use of two motors. These motors are connected first in series and then in parallel. Two running speeds are obtained, one with the series connection and the other with the parallel connection. In starting with both motors in series only half the current is required to develop the same torque as in starting with both motors in parallel, or with one motor of twice the capacity. The disadvantage of such a system is the complication involved in the control apparatus and the use of two motors, which adds to the expense and slightly decreases the efficiency.

Multi-Voltage System

The multi-voltage system consists of three or more line wires with different potentials. The motor is connected between pairs of these wires. With four wires, whose voltages have been properly chosen, at least six different running voltages can be obtained. Such a system in its simplest form consists of the three-wire system. The motor is connected first across the 110-volt mains and the speed of the same varied by changing the field strength. It is then connected across the 220-volt mains and another range of speed obtained by variation of field strength. Additional wires give a wider speed range with less variation in field strength, which in some cases effects a saving in the weight of the motor. This system involves considerable complication, as the controller must be arranged to insert resistance into the armature circuit of the motor when passing from

one voltage to another. This is particularly necessary in going quickly to the off position. Balancers have to be used to equalize the load between the different wires in this system.

Machine-Tool Application

Such a system of control has generally been applied to machine tool work. Machine tools require approximately a constant output of the motor over the complete range of speed. As the power absorbed by a motor is equal to the current times the voltage at the motor terminals, it is evident that at a low voltage the motor must take a much heavier current to develop the same power. Since the motor may run for a long time at the slow speeds this makes it necessary to provide very heavy lead wires from the balancer to the motor.

This method of control was generally used in the early days of motor application to machine tools. Later developments, however, have resulted in placing on the market motors which can give wide speed ranges with the single voltage. Due to the simplicity of such a device the old voltage system is being superseded, except in special cases.

The multi-voltage system of control can not be supplied from a two-wire power circuit without the use of a motor-generator set. The three-wire system can be supplied from any three-wire power circuit without the use of auxiliary generators where unbalancing is not too great, and for this reason is better adapted for central-station power. Several methods of controlling motors by means of storage batteries, or a small motor in series with the main motor, have been suggested. These methods generally consist in connecting the storage battery so that it first opposes then adds to the line voltage. The auxiliary motor is used in the same manner. While this form of control would probably give very good results in practice, the cost of the apparatus is prohibitive, except in special cases.

ALTERNATING CURRENT

Induction Motor and Auto-Transformer

The polyphase induction motor with short-circuited secondary is usually started by changing the voltage impressed upon the motor terminals by means of a transformer; usually an auto-

transformer is employed. This device is simply a single-coil transformer from which a number of taps are brought out to give various voltages. The motor is connected to the line on one side and to a tap of the transformer on the opposite side. The current in the line is less than the current in the motor in the inverse ratio of the voltages. Figure 1 represents the effective current in a two-phase motor and power circuit. When

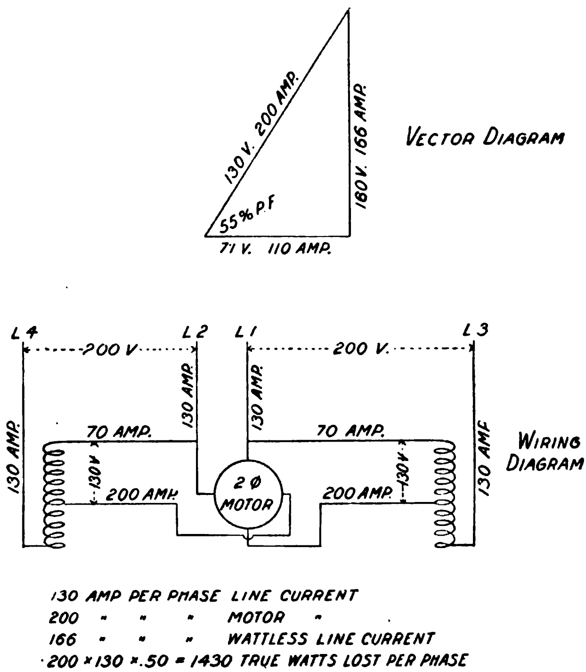


FIG. 1—WIRING DIAGRAM TWO-PHASE MOTOR AND POWER CIRCUIT

the motor is connected to a tap which impresses 130 volts across the motor terminals with a line voltage of 200, it will be seen that if the line current is 130 amperes and the motor current 200 amperes the transformer supplies the additional 70 amperes by which the motor current exceeds the line current. This method of starting draws the minimum current from the line. In the above example the true watts in one phase, assuming 55

per cent power factor, are 1430 watts, the wattless current is 166 amperes.

If a resistance were used in series with the secondary of the motor (Figure 2) in order to reduce the voltage across the motor terminals, the line current would have the same value as the motor current, and instead of the small losses from the auto-transformer we should have the still greater loss due to the

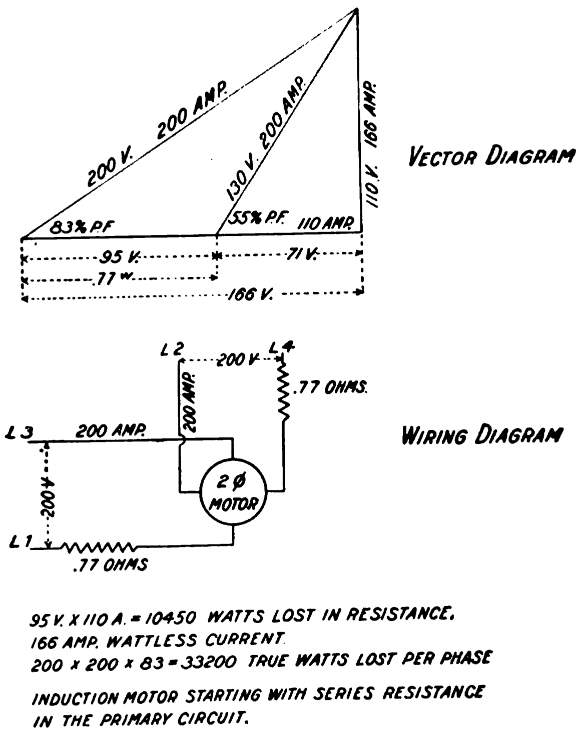


FIG. 2—INDUCTION MOTOR STARTING WITH SERIES RESISTANCE IN THE PRIMARY CIRCUIT

energy consumed in the starting resistance. By referring to Figure 2 we have assumed the same starting conditions at the motor terminals as in the previous example, namely, 130 volts across the motor terminals and 200 amperes in the motor circuit, 55 power factor and 166 amperes wattless current. By referring to the vector diagram it will be seen that this triangle is the

same as the triangle for the motor when started from an auto-transformer, shown in Figure 1. In order to reduce the 200 volts in the line to 130 volts at the motor terminals, it is necessary to insert 0.77 of an ohm resistance in each phase of the motor circuit. This increases the power factor to 83 per cent, but the wattless component of the current remains the same and the energy drawn from the line is 33,200 watts, neglecting minor losses. By comparing this with the 1430 watts loss in starting the same motor from an auto-transformer, it will be seen that not only is the line current reduced at the time of starting, but the actual energy consumed is less than one-half when an auto-transformer is used. The above figures are approximate only, as the losses in the motor, transformers and the lead wires are neglected. The figures, however, represent approximate commercial conditions, and the losses given are for one phase only; for a two-phase motor they will be doubled. From the above it is easy to see why all commercial induction motors are started by means of an auto-transformer, and that the use of series resistance, while it improves the power factor, does not reduce the wattless current or improve the regulation, but increases the amount of current taken and makes an inefficient starting device. In such cases as this the improving of the power factor is a decided disadvantage. In fact, the power factor could be increased by this method even with an increased wattless current and decreased regulation.

Comparing these motors with the series commutator type motors with which series resistance is used to control the same, we would state that undoubtedly better conditions could be obtained with an auto-transformer, but with the series motor, the torque is approximately in proportion to the square of the current, so that a small variation in the current makes a considerable variation in the torque, as explained under "The Control of Direct-Current Motors." For this reason the current taken by the series motors in starting is not nearly so great as that drawn by an induction motor, and the use of series resistance for crane service, for instance, materially simplifies the control apparatus; for this reason it is used in the same manner as with direct-current motors. A voltage system of control would be somewhat more efficient, and where step-down transformers are available, such as in railway work, these series motors are controlled from taps on the transformer.

Multi-Point Auto-Starters

When starting a motor where the torque increases with the speed of the motor and the load is comparatively light, at starting, a multi-point "auto-starter" or "compensator" should be used. This enables the motor to be started with a low voltage and consequently a small line current. As the speed of the motor increases, higher voltages can gradually be applied until the motor is brought up to full speed at the line voltage. If, on the other hand, a double-throw switch were used in connection with such an auto-transformer, only one starting notch would be available, which would materially increase the amount of current taken at the time of starting. Centrifugal pumps, fans and similar apparatus are well adapted for starting with the multi-point auto-starter, as the torque of this apparatus varies as the square of the speed, and considerable saving can be effected and the maximum current materially reduced by the use of this kind of a starting device. For motors up to 50-hp starting device with three points can readily be obtained; for larger motors six and nine-point starters are available. These starters are all of the drum type. The most approved designs have no moving wires connected to the drum, all contacts being made by fingers pressed against metal clips mounted on the drum. These fingers and clips should be removable, so that the controller can be readily repaired if the contact surfaces have been burnt by arcing. When the tanks are heavy mechanical lowering devices are provided.

Where heavy loads are to be started which require considerable torque to overcome the static friction, but where the running friction is comparatively light, such as a long line shaft, it is necessary to apply considerable voltage to the motor terminal to start the load, and in most cases this voltage is sufficient to bring the motor up to practically full speed, so that a double-throw switch is all that is necessary. In fact, it is an advantage to apply the voltage suddenly to the motor terminal so as to jar the load loose. By suddenly applying this voltage the maximum current taken at starting can be appreciably reduced.

Where a double-throw switch is used for starting these motors it is generally because the starting conditions are severe, and for that reason considerable current will have to be handled by the switch. Separate removable arcing tips should be provided of very rugged construction.

Recent tests made indicate that arcing tips can be provided which will open the full-load current of the switch from 1500 to 2000 times before being renewed. When a switch of this kind is used in a factory the motor is generally started but twice a day, so it will readily be appreciable that arcing tips of this character will last for several years without being renewed. This, however, does not mean that they should not be properly inspected, as sometimes short circuits occur which materially reduce the life of an arcing tip.

The use of an induction motor with a short-circuited secondary does away with all motor troubles and concentrates them at the controller. This has rendered the design of switching devices for these motors quite difficult. This problem has received special consideration, with the result that several different types of starters have been placed on the market, all of which employ an auto-transformer to reduce the line current. The application of the proper starter depends upon the load which the motor starts.

Fuses

Where fuses are used, in starting induction motors with short-circuited secondaries, the starting devices should be arranged to open-circuit the fuses in the starting position. In some cases the fuses have been short-circuited, but the resistance of the fuse is small, and where the lead wires for short-circuiting purposes are long, their resistance is considerable, so that the short-circuit is not always effective. The general method employed is to run wires from the feeders direct to the devices and use these in the starting positions. In the running position other wires are used which connect to the fuses.

Auto-Transformers

Where a two or three-point starter is used the auto-transformers should be provided with a number of extra taps so that the starting voltage can be adjusted to suit the load. The auto-transformers furnished should be able to withstand the magnetizing current continuously, so if through accident they are left connected across the line in the running position they will not burn out. These transformers should be properly enclosed,

so that there will be no fire risk if the transformer is burnt out in starting the motor.

Commercial transformers can be obtained which fulfil the above functions admirably. A very common form consists of an ordinary transformer having case-iron caps placed over each end to cover the windings, the central portion of the transformer having the iron exposed. This gives a good radiation. A burnout test made on this type of transformer did not heat the exterior of the iron sufficiently to cause a fire risk. The heavy white smoke emitted under these circumstances is of itself a splendid warning.

Series Parallel Control

Series commutator-type motors can be controlled by placing two motors, first in series and then in parallel, in the same manner as with direct-current motors. This method, however, is seldom used, as the varying of the voltage at the terminals of these motors can be done very readily by use of an auto-transformer. These motors can be used on both alternating current and direct current, and when operating on direct-current lines are sometimes controlled by this method.

Cascade Connections

Polyphase induction motors can have their speed varied by using two motors of the slip-ring type, the secondary of the first motor being connected to the primary of the second motor. This method is commonly called a cascade connection. The speed of the combination is equivalent to the speed of a single motor having a number of poles equal to the sum of the poles on the two separate motors. This method of control has been used in traction work and will probably be used in large industrial installations where two or three fixed speeds are required. Intermediate speeds can be obtained by resistance in the secondary of either motor. Where the two motors are of equal power with a different number of poles three speeds can be obtained. First, with both motors cascade giving the lowest speed. Second, with the motor having the larger number of poles. Third, with motor having the smaller number of poles. In each case the power delivered will be the same, provided the two motors have the same horse-power capacity.

Changing Field Strength

Changing the field strength is a very common method of controlling direct-current shunt and compound-wound motors, where it is desirable to have the speed remain constant on each notch of the controller independent of the load. Commercial motors can be obtained having speed ranges as high as five or six to one by this method of control. However, there is very little demand for motors with more than a four to one speed variation, and even these motors represent but a small portion of the demand for this class of motor. By far the greatest number of motors are sold having a two to one speed range. The application of these motors has generally been made to machine tools and printing presses. Wide variations in speed of machine tools are obtained by mechanical devices; for instance, a lathe with a 20 to 1 speed variation driven by a motor with a four to one speed variation would require approximately two mechanical speed changes to obtain the total range of speed. This method of control is very efficient, as the only power lost in resistance is due to the shunt field current which represents a very small percentage of the energy of the motor. The speed is practically constant on every notch of the controller independent of the load.

This control is generally effected by means of a drum-type switch which reverses the motor and provides the necessary starting notches by armature resistance. In the same frame with the drum switch is mounted a face plate which controls the amount of resistance in series with the shunt field. The control is so arranged that in the off position all of the resistance is inserted into the shunt field circuit. On the first starting notch this shunt field resistance is short-circuited; after the motor has been brought up to speed this resistance is gradually inserted in the circuit to reduce the field strength and increase the speed of the motor.

Automatic Acceleration.

As the size of these motors increases it is probable that a form of unit switch control will be found necessary. Such a control gives automatic acceleration in starting the motor, removes all armature circuits from the hand-switching device and permits

of a powerful blowout being employed which will increase the life of the contacts. With such a control a very small master switch can be used mounted in combination with the field rheostat. The difficulty of furnishing large drum-type controllers is due to the heavy contacts required for the main line current. This makes the controller difficult to operate, particularly when the contacts are partially burnt and have become rough.

Several unit switch controllers were furnished a year and a half ago for motors developing as high as 450 horse-power with a speed range of 1.5 : 1. These motors have been in operation under severe conditions ever since that date with no trouble from the controller.

Changing the Number of Armature Conductors in Series

As the speed of the motor, other things being equal, depends on the number of armature conductors in series, efforts have been made to vary the speed of the motor by changing the arrangement of these conductors. The most common method employing this principle is the double commutator motor. The difficulties experienced seem to be confined to the design of the motor itself. The objection to the double-commutator motor, other than the cost of same, is the difficulty of balancing both sections so that the two ends can be run in parallel. The controller for this motor is a combination of the series parallel control with field rheostat for obtaining the intermediate speeds.

Changing Number of Poles

Changing the number of poles is a very effective way of varying the speed of a motor. At the same time, however, it varies the power the motor can deliver and adds other complications. The writer does not know of any practical application of this principle for direct-current motor.

ALTERNATING CURRENT

Two-Speed Induction Motor

The polyphase induction motor is furnished with two sets of poles, one set generally having twice as many poles as the other set. These are known as the two-speed induction motors and have

been used in a good many cases. The control generally consists of a standard auto-starter and a double-throw switch for effecting the change in the number of poles. This method of control has been applied, in general, to motors with short-circuited secondaries. In one or two instances such motors have been built with slip-ring secondaries in which external resistances are furnished. This type of motor, however, is exceedingly complicated, as the secondary must be provided with a double winding corresponding with the double sets of poles in the primary. For this reason these motors have not been developed.

With a motor having two sets of poles care must be taken in passing from the high-speed to the low-speed combination. If the motor is running on the high speed and the connections are changed to low speed, a dynamo action is set up and the torque of the motor is reversed in the same manner as in changing the voltage across the terminals of a direct-current motor operating on a multi-voltage system. This dynamo effect is very severe and proper precaution should be taken to protect the apparatus from mechanical strains. The usual method of changing the speed of such a motor is to open the switch which changes the number of poles and allow the motor speed to drop to approximately slow speed before the switch is closed on the slow-speed side.

Alternating-current single-phase motors can be controlled by introducing resistance in shunt with the field. Owing to the good design of these motors considerable variations in speed can be obtained in this way without interfering with their commutation.

MECHANICAL DEVICES

Gearing and Clutches

Gearing, clutches, *et cætera*, are generally used in connection with motors whose speed is changed by changing their field strength. The old method of controlling the speed of machine tools was done entirely by mechanical means and generally gave few steps with wide variations in speed between steps.

Kohler System

Two or more motors have been used for obtaining different speed variations in the same piece of apparatus. Probably the

best known application of this method is that made to printing presses of large size, where a small motor is used for operating the press at the slower speeds, and a larger motor for the high speeds. The control for such a system generally consists of a panel on which is mounted various switching devices controlled by solenoids. This control can be operated from a number of stations by means of a master switch or a series of push buttons. The mechanical connection between the machinery and the slow-speed motor is made by means of a clutch, so that the low-speed motor can be disconnected from the system at the higher speeds.

Variation in Air Gap

Two types of motors have been placed on the market in which the gap between the armature and the field poles is varied. In one of these the iron of the field poles is withdrawn by means of mechanical gearing. In the other type of motor the armature is moved parallel with the axis of the shaft. Both types require mechanical devices for balancing the magnetic pull on the parts which are moved. At present the application of this device has been quite limited.

Centrifugal Devices

In a number of instances centrifugal devices have been used for starting motors. One application consists of a single-phase induction motor, which is started up as a repulsion motor and the connections changed to an induction motor after the speed has reached a fixed limit.

Another application of this principle is entirely mechanical. The single-phase induction motor is started light; after it has attained considerable speed the centrifugal device grips the pulley to which the load is belted.

BRAKES

Two general methods of braking or stopping an electric motor have been employed, and as their operation depends largely upon the controller they should be considered as a part of the control system.

Dynamic Braking

The dynamic brake consists in short-circuiting the armature through a suitable resistance, either having the series field in the circuit or having a shunt field excited from the line. The principle consists in making the motor operate as a generator, the load consisting of the internal resistance of the motor and whatever external resistance is used.

Shunt motors are very often used in this way and are very reliable. The shunt field is excited either by the motor e.m.f. or is left connected to the line.

Mechanical Brake

A mechanical brake is generally released by means of a solenoid and applied by a spring or weight. Shoe, band, and disc brakes are used and each has its particular advantage. All three forms can be made to operate satisfactorily by careful design. At the instant of application the stored energy of the moving parts causes the brake to grip the wheel with considerably more than the normal torque. In some instances this excess torque is two or three times the normal. In properly-designed brakes the stored energy of the moving parts is compensated so the shaft does not receive excessive strains.

Heating

Where brakes are used often the energy absorbed by the brake causes excessive heating unless proper means are provided for radiating this heat. The problem is the same as the heating of electrical machinery, although the mechanical parts of the brake may be run at a very high temperature provided the magnet coil is kept at a low temperature. The temperature of the brake itself is only limited by the material of which it is made. For instance, organic substances will deteriorate at 100 to 150 degrees centigrade while the cast-iron shoe of a railway brake can be run 200 to 400 degrees centigrade.

METHODS OF REDUCING THE LINE CURRENT AT STARTING

Very often the consumer finds after the motor has been installed that the starting of this motor causes considerable drop in the line voltage, and the question naturally arises, in what way

can the starting conditions be improved? Below is a table giving in a general way different methods which may improve the starting conditions of the motor. Any improvement depends entirely upon the condition of the load, the characteristics of the motor and the type of starting device or controller that is already in use.

(1) Increasing the number of steps.

(2) Jarring the load loose, by suddenly applying the power.

(3) Increasing the field strength. (Compound winding.)

(4) Ilgner System. Using a motor-generator set with a heavy fly wheel.

(5) Substituting automatic acceleration for hand starting.

(6) Starting the motor light and using a clutch to pick up the load.

(7) Substituting an auto-transformer for a rheostatic method of starting alternating-current motors when the control is in the motor primary.

(8) Increasing the number and decreasing the size of the motors.

(9) Increase the slip of an induction motor.

These methods have all been discussed in the previous part of this paper and will not be dealt with here.

APPLICATION OF MOTORS AND CONTROLLERS

In the following the different applications of electric motors have been taken up and the types of controllers applicable for the different service conditions have been noted briefly. The treatment has necessarily been general and can cover only a few of the many applications of motors for industrial purposes. The methods of control noted are explained in the early portion of the paper.

CRANE

The controller should be arranged for remote control by bell crank and levers or master switch. Handle should have reciprocating motion. Controller should be narrow.

Direct Current

Use series motors controlled by resistance in the armature circuit. The torque is proportional to the $(\text{current})^2$. A series brake coil is used so no brake switch is required. The unit

switch type is advisable for heavy service where few steps are necessary.

Alternating Current

Series motor single-phase controlled by armature resistance same as direct-current motor. Shunt brake coil, separate brake switch.

HOIST

The controller should be protected from weather.

Automatic acceleration is often desirable.

An automatic stop at the top and bottom limits of travel can be arranged as in elevator work.

Direct Current

Series motors are used where the hoist is always under load, and compound motors where the load is lowered and motor is apt to run away. The control is by armature resistance. A dynamic brake can be used with compound-wound motors.

Alternating Current

Slip-ring induction motors are controlled by resistance in series with secondary. This motor has a fixed speed limit and controls like a direct-current shunt motor.

CENTRIFUGAL FANS

Direct Current

Shunt motors are used and controlled by both armature resistance and shunt field variation. The torque and current decrease approximately as the square of the speed, so the power absorbed in armature resistance is small.

Alternating Current

Polyphase induction motors are used with resistance in the secondary circuit. The loss is the same as with direct-current shunt motors having armature resistance. Automatic devices for starting have not yet come into use.

PUMPS

Plunger pumps have constant torque and heavy starting conditions. The loss by armature resistance control is directly proportionate to reduction in speed, therefore, field control is preferable.

With centrifugal pumps the power is inversely proportionate to the head so the speed of the motor should be reduced when the head is reduced. The torque varies approximately the same as a fan.

Automatic starting devices can be obtained for small constant speed, alternating-current motors and all direct-current motors.

PRINTING PRESSES

Direct-Current Shunt Motors

The control has automatic overload and no voltage release and push-button release. The power is proportionate to the speed.

The slow speeds are obtained by low voltage from a small motor-generator set (Teaser System); higher speeds by field control. One motor-generator set can be used for several presses.

Controlled from a two-voltage three-wire system the slow speeds are obtained by armature resistance and the higher speeds by field control.

Kohler System—Here a small motor is used for slow speeds and the main motor for operating speeds. Both armature resistance and field control are used. The small motor brings the main motor up to a slow speed and is then disconnected by a clutch.

MACHINE TOOL—DIRECT CURRENT

Shunt and Compound-Wound Motors

The control is obtained by varying the field strength. A 4:1 speed variation can be obtained on one voltage. A simple drum-type controller is used for reversing the motor and providing the starting notches. A face plate mounted in connection with the drum inserts resistance into the field circuit. No automatic attachments used at present, but this control will probably develop into automatic acceleration for larger motors. The resistance for the

field should be adjustable to suit conditions, especially for compound-wound motors.

The multivoltage control, in addition to the features mentioned above, should have an automatic device to insert resistance into the armature circuit in passing from one voltage to another, especially when coming quickly to the off position, it has fewer steps by field control.

MILL TABLES

Generally Direct Current

Use series or compound-wound motors designed for quick reverse; controlled by resistance in armature circuit. Both motor and controller must withstand severe usage. Controller handle should have reciprocating motion. For large motors a unit switch controller should be used operated from a master switch and adjusted for quick action.

MILL ROLLS

Three-High

Both alternating-current and direct-current motors are suitable. These motors are mounted on the same shaft with a very heavy fly wheel, and their speed is adjusted so the fly wheel will take the peak of the load.

Two-High

Direct-current motors only are applicable; some form of motor-generator system of control will probably be used, but such an cutfit has not yet been installed.

MISCELLANEOUS STEEL MILL CONTROLLERS

Generally alternating-current induction motors are used for constant-speed work controlled by an auto-starter. For variable speed both direct-current series and compound-wound motors are used, controlled by resistance in the armature circuit.

COTTON, WOOLEN AND SILK MILLS

The alternating-current polyphase induction motor is used entirely, because of the fire risk due to lint.

Group drive controlled by auto-starters or secondary resistance, preferable exterior to motor. Controller must be entirely enclosed and dustproof.

The individual drive by small motors thrown directly on the line is being developed and will be used considerably in the future. The absence of line shafting and belting materially reduces the fire risk and repairs.

The President: This paper is now open for discussion. If there is no discussion, the meeting will stand adjourned until half after eight o'clock this evening.

SIXTH SESSION

President Blood called the meeting to order at a quarter after eight o'clock, and said: "I am going to ask to preside over this meeting to-night a gentleman who needs no introduction, one who is well known to all of you—Mr. T. Commerford Martin."

MR. MARTIN: Mr. President, Ladies and Gentlemen—The programme of the National Electric Light Association at this twenty-ninth meeting includes a great many topics of first-class importance. Many of these are of a technical and esoteric character, of very little interest to the general public and hardly to be understood by any except those expertly trained in the art. There are other questions on the programme of the association that enter upon and touch deeply the problems of the daily life of every citizen of this great republic. I do not know that I could mention at this moment any question of greater interest than that of municipal ownership. For my own part, if I may be permitted modestly to say so, I hardly consider that question one of deep and permanent interest. In this country, with our freedom of expression, new questions entertain and interest us from year to year, and we are open to each new wind of thought and doctrine. Fortunately, we live through our fads and fancies and quickly determine between those questions that are emotional and go to the heart of the nation and those that are strictly economic and can not by any sensational methods be brought into the other category. To-night, ladies and gentlemen, we shall consider an economic and not an emotional question. I shall have the pleasure of introducing to you a gentleman by no means unknown to the National Electric Light Association, one who came before us at least a score of years ago and who in the interval has devoted his time and thought, as a great constitutional lawyer and as one of the ornaments of the New England Bar, to the consideration of those questions affecting the relations between the public and the corporation. I believe that before he closes his address the speaker of the evening will have cleared up for us a great many of the hazy notions and a great many of the absurd statements that have been put before

the public with regard to the attitude of the corporation toward the public and the relations of the public to the corporation. I believe that he will enable us to see more clearly than we have seen before the manner in which we can preserve our individual freedom and yet limit and restrict our economic wastes.

It is with much pleasure, therefore, Mr. President, ladies and gentlemen, that I introduce to you the speaker on the subject of *The Agitation for Municipal Ownership in the United States —Its Origin, Meaning and Proper Treatment,* Mr. Everett W. Burdett, of Boston.

Mr. Burdett presented the following address:

THE AGITATION FOR MUNICIPAL OWNERSHIP IN THE UNITED STATES—ITS ORIGIN, MEANING AND PROPER TREATMENT

A spirit of unrest and discontent is abroad in the world. Although men are better off to-day than they ever were before, and industrial conditions are superior to any known in history, the masses and the working classes are arrayed against capital, and in some instances against the social order.

Great accumulations of wealth in the hands of a few, generally employed in corporate organizations, have so abused the privileges which wealth and organization put at their disposal that the average citizen is disgruntled and inclined to demand a change of some kind which will tend to remove the inequalities of which he deems himself the victim. In short, a great socialistic agitation is upon us, which may result in far-reaching economic changes. Capital looks aghast at the armies of labor which are arrayed against it, and the working classes view the further accumulation of wealth and extension of corporation activities as a menace to their welfare. Socialistic doctrines are finding new adherents, and the professional agitator is winning new recruits.

To the forces which are professedly and violently socialistic have been added large numbers of persons, many well intentioned, who, without consciously adopting the doctrines of socialism, are giving public affairs a decided impetus in that direction. They have seen great railroads exposed in giving secret rebates, which have enriched their recipients and impoverished the unfavored shipper. They have seen these expedients employed to suppress competition in the products of the soil and the necessities of daily life. They have thus beheld the great highways of travel and of traffic, which ought to be opened upon the same terms to all alike, turned into royal roads to riches for some and direct lines to the poor-house for others.

They have witnessed enormous accumulations of cash and securities in the coffers of life insurance companies, rightfully

belonging to policy-holders and their beneficiaries, become, in the hands of corporate officials drunk with financial power and unchecked by adequate supervision or control, enormous corruption funds for any uses to which the whims of their managers may see fit to put them. Inordinate inflations of corporate capital by consolidations and otherwise, to amounts which fairly stagger the imagination and which a few years ago were not even dreamed of, have been made for no good purpose, but solely to enable promoters, bankers and speculators to make enormous initial profits, resulting in grievous additions to the permanent burdens, already heavy, under which the consumer and the general public must stagger for indefinite periods.

Necessary provision of law for the raising of public revenues and the reasonable protection of American labor and capital from foreign competition have, in many instances, been perverted for the unreasonable enrichments of the few at the undue expense of the many.

Corporate power has, in too many cases, been used to exact high prices for poor service, to secure enormous returns on fictitious capital, to pay extravagant salaries and support wasteful expenditures, to secure legislation to enrich the few at the expense of the many, in short, to further the interests of those wielding the power, to the detriment and destruction of those upon whom it has been exercised.

Forgetting the beneficent results that have been obtained only through the accumulation of great wealth from corporate organization, the dissatisfied citizen sees only the abuses of financial and corporate power of which he has been, or imagines himself to be, the victim. The very word "corporation" has come to have an approbrium of its own.

And yet, of course, this wholesale distrust and condemnation of wealth and corporate power is unreasonable. It loses sight of the fact that we are unable to assert from what other source the people at large would have derived the blessings which have come from the establishment and maintenance of the almost countless hospitals, libraries, colleges, parks, museums and special funds for the encouragement of learning, the promotion of science, the reward of courage and endeavor, and the various other beneficent uses for which they have been established and maintained by private wealth, largely derived from corporations. They forget that

it has been only by the uniting of the funds of the rich and the savings of the poor in corporate organizations that the country has been developed by the establishment and exploitation of numberless forms of industrial enterprise, which have given employment to labor, activity and volume to trade, and a market for all the products of our soil, and all the talents of our people.

In electrical enterprises the central-station electric lighting investment alone already aggregates 700 million dollars, involving an annual operating expense of nearly or quite 100 millions, distributed among all classes of workmen and through every artery of trade. The census reports show that in the single year 1904 there was an output of new electrical apparatus of the value of more than 150 millions. There are nearly 5000 central electric lighting stations. There are 23,000 miles of electric railway, carrying each year over 5000 million passengers. A network of nearly 300,000 miles of steam railroad gridirons the country, transporting upward of 750,000,000 passengers annually. Spoken words are transmitted through more than 5,000,000 miles of wire, by the use of more than 3,000,000 telephones, by which more than 5000 million messages are transmitted yearly.

All these wonders we owe to our corporations. They have given free play to the enterprise and individual energy of our people, and have made that enterprise and energy vastly more powerful and effective than it otherwise could possibly have been. They have enabled the man of small means to do a part of the world's work by joining his savings to the capital of his wealthier neighbor. They have encouraged thrift and the spirit of investment. They have advanced civilization and brought to every man's door the diversified products of our own and other countries.

And it has been, not the organizers, managers and stockholders of these enterprises who have chiefly benefited by them, but the general public. It is unquestionably the fact that the public at large have, upon the whole, obtained vastly greater benefits from corporate enterprises than have those whose money has made them possible.

A glance at the net divisible incomes earned and the dividends paid by the electrical public-service corporations of the United States, contrasted with the character and extent of the service rendered by them to the public, will furnish ample demon-

stration of this assertion. Take the state of Massachusetts, for example; it has ninety-eight electric railways, operating 2688 miles of track, transporting over 500,000,000 passengers by the use of 7341 cars. Only about one-third of them paid a dividend in 1905. Sixty-three paid no dividends at all, while the other thirty-five paid from two to ten per cent, with an average dividend of four and one-half per cent, which, if applied to the capital of all the companies in operation, would have yielded an average dividend of less than two and one-half per cent. At the same time these companies paid into the public treasury in the form of taxes nearly $2,000,000.

In the same year there were in Massachusetts fifty-eight strictly electric lighting companies, only about one-third of which paid any dividends whatever. The dividends paid ranged from four to ten per cent. These companies paid into the public treasury in the form of taxes nearly $600,000.

It thus appears that the tax-gatherer, the employee and the general public have each and all reaped rewards vastly greater than have been realized by the stockholders in these enterprises. But, fortunately, the conditions are improving; and even the disappointed investor begins to realize some reward for his courage in establishing and developing these industries. All tendencies are in the right instead of in the wrong direction, and are constantly diminishing the necessity, if it ever existed, of a change from private to public ownership.

But, notwithstanding these improvements along all desirable lines of progress, I attribute the existing widespread agitation for the municipal ownership and operation of public utilities very largely to the influence upon the popular mind of the widespread dissatisfaction and resentment occasioned by the abuses of great wealth and corporate facilities, to which I have referred.

And it has not been alone in the direction already indicated that great wealth has been unfitly and objectionably employed. It has also, in some conspicuous instances, been extensively used for the express purpose of fanning the flames of discontent and sowing the seeds of popular hostility to the established order. "Yellow journalism" is not the product of anarchism or the slums, although it encourages anarchy and exploits the slums. Great wealth in this instance has been perverted to the despicable employment of setting man against man, and class against class; of

making the contented discontented, and the discontented desperate. Instead of seeking to promote "peace on earth and good will to men," this baneful influence has invoked the lowest motives and kindled the fiercest resentments. Instead of appealing to reason, it has aroused passion; instead of seeking to improve conditions by accepted methods and through regular channels, it has preached social, industrial and political revolution. Instead of employing the instrumentalities of established government, it has sought to set up the rule of the mob, sometimes under the guise of the *referendum.* Instead of employing the vulgar methods and the heartless brutalities of a Robespierre or a Danton, it has attempted the overthrow of the established order by resort to methods, hardly less vulgar or heartless, though necessarily more in keeping with the conventionalities of modern times. The results sought to be accomplished are substantially the same in both cases—the transfer of power and property from one class to another.

One of the most baneful results which this last-mentioned employment of great wealth has accomplished is the demoralization of politics and political conditions in different sections of the country. The politician, particularly the local politician, has discovered, or thinks he has discovered, an easy road to office and emolument through catering to and increasing as much as possible the popular discontent and hatred of the established order, which yellow journalism has created and fostered. He sees votes, for example, in municipal ownership, as the old-time Northern politician used to see "just one more election" in the "bloody shirt." He therefore shouts for the municipal ownership and operation of anything and everything with which the people are not fully satisfied; and, from the very nature of the services they render, public-service enterprises never did and never can satisfy all the demands, reasonable and unreasonable, which are made upon them. Like the Irishman who was wrecked on the shores of an unknown land, and immediately declared that he was "agin the government," whatever it was, the average citizen feels more or less hostile to the railway, lighting or telephone company, whose service, however good, he thinks might readily be improved.

The politician, whatever his faults, can at least lay claim to a knowledge of human nature—at any rate, that kind of uneducated human nature to which he principally appeals. He is there-

fore quick to seize upon the inevitable deficiencies in existing public services as an object of his disinterested criticism, and to make the most of them for his patriotic purposes. He it is, therefore, who is found preaching the beauties of municipal ownership in season and out of season, pointing out how wretchedly the responsible people now in control of quasi-public utilities are managing them, as compared with the ideal conditions which would prevail if he and his like were put in charge of them.

I do not mean to be understood as asserting that all supporters of municipal ownership in this country belong to either or any of the classes to which I have alluded. There are many sincere, patriotic and thoughtful people who are convinced of the efficiency and desirability of municipal ownership—at least as a choice of evils. I only mean to be understood as saying that the latter class, however numerous, would be wholly ineffective in converting our system of private ownership and control without the cooperation of the other classes to which I have specially referred, and which constitute by far the greatest forces favorable to municipal ownership in this country.

Another most potent reason for the popularity of the idea of municipal ownership in the United States remains to be considered. It is the one that has, perhaps, most strongly appealed to all classes of its advocates. I refer to the experience of British municipalities in public ownership. The result of this experience has almost if not quite uniformly been stated favorably. Our people have come to think that in England, certainly, the experiment of municipal ownership and operation has been amply justified by results. The favorable features of municipal ownership abroad have been so iterated and reiterated by writers and speakers in this country that the body of our people have come to assume that there is no other side of the discussion. They have therefore naturally fallen into the habit of asking, if municipal ownership has worked so well abroad, why is it not a good thing for this country.

This query, though natural under the circumstances, is inspired by a superficial knowledge of the facts. Those who have known better have not troubled themselves to set the matter right; those most directly interested against the proposition have failed to protect their own interests by entering into the discussion; those who should have been conducting or inspiring a

comprehensive campaign of education have sat supinely by and allowed the doctrinaires to monopolize the public attention. So far as my observation has gone, there have been few serious efforts made to counteract the assertions of the theorists and partisans of municipal ownership, who have lost no opportunity, in season and out of season, to influence the public mind in favor of their propaganda. A golden opportunity has been lost; the mischief has been largely done: misrepresentation of facts and statements of false conclusions from insufficient or inaccurate data have gone so far without challenge that any campaign of education which may now or hereafter be inaugurated, needs be more onerous in character and uncertain in results than it otherwise would have been. But it is never too late to begin any good work. The character of the work needed is apparent. It remains for those in interest to determine how aggressive and effective it shall be.

In pointing out the fallacy of adopting municipal ownership in this country on the strength of its alleged success abroad, the first thing to be suggested is the danger that always lies in the off-hand adoption of foreign methods, laws or practices of another country. It can seldom be done successfully. Differences in political, economic or social conditions almost always exist which render the transmitting of the laws, customs or methods of one country into another inexpedient. We are, for example, inclined to laugh at the administration of French justice. To us it seems a travesty, resulting in a comedy or tragedy, as may be the case. But the fact is that in that country it produces good results, and in some cases I am inclined to think, better results than are worked out under our entirely different system of jurisprudence.

The *adaptation* of foreign practices to the conditions prevailing in another country is, however, frequently desirable. Almost if not all civilized communities can contribute something of value to and get something of value from others. But such adaptation needs to be done with care and discrimination, in order that under the changed conditions it will not do more harm than good.

Keeping in view these general observations, let us examine as briefly as may be the alleged success of municipal ownership in Great Britain, in order to determine how far it justifies the inference that its adoption is desirable in this country.

The first thing to be noted is that the origin and meaning of municipal ownership of certain utilities were entirely different abroad from what they are in this country. We have not, and never have had, any such conditions of things, for example, as not only justified but practically forced the adoption of the public ownership and control of gas and electric lighting in the principal cities of Great Britain.

The city of Glasgow led off in this departure. In 1865 the congested area of Glasgow contained eighty-eight acres, with a population of 51,294, or an average density of nearly 600 to the acre, and in some sections more than 1000 to the acre. The average mortality for some years had been over thirty-eight in the thousand, epidemic diseases accounting for thirty-six per cent of the death rate. The city engineer said that "almost every spare inch of ground had been built upon, until room could not be found to lay down an ash pit." There were practically no streets at all, but only a system of lanes or closes permeating an almost solid mass of tenements of the worst description.

In 1871 over thirty per cent of the inhabitants of Glasgow lived in tenements of one room only, and ten years later 126,000 were thus inadequately and indecently housed, while 228,000 were still huddled in tenements of two rooms only. As late as 1891 nearly one-half the people lived in one-room and two-room tenements. The medical officer of Glasgow stated that there were thousands of these one-room tenements which contained five, six and seven inmates and hundreds that were inhabited by from eight to thirteen. In view of such conditions, one can readily assent to Dr. Albert Shaw's conclusion, that "considerations of the public health have been predominant in determining the most important lines of action entered upon within the last quarter century by Municipal Glasgow. . . . These new municipal undertakings find their true centre in the Bureau of the Medical Officer of Health." (Municipal Government in Great Britain, p. 30.)

The conditions in Glasgow were characteristic of those in other important cities of the Kingdom. There, as elsewhere, conditions were so bad that it was deemed absolutely necessary that the municipality should deal with them with a free hand. It must open streets, and for that purpose must demolish houses. It must see that the people were decently housed, and it was

decided to build houses for them. It was necessary that the people should be washed, and it was deemed wise to establish public wash houses and also public laundries. In short, municipal ownership of lighting facilities, or workmen's dwellings, of public laundries, wash houses, and so forth, was the result of necessities of which we happily have no personal knowledge in this country. And, having gone thus far, it was easy and natural to go farther. One of the most dangerous incidents of municipal ownership is the ease with which the idea can be expanded in practice. It is entirely logical for the advanced municipalists of England to declare, "There is no finality to municipal enterprise; we can not limit our horizon."

But it is not necessary for the purposes of this paper, however interesting and instructive it might be, to trace municipal ownership in Great Britain or other foreign countries to its sources, or to state the reasons for its expansion. Suffice it now to say that they were very different from those existing in this country.

Moreover, the differences in the conditions surrounding the prosecution of public utilities there and here are all-important. The most important, perhaps, of these is the fact that European, particularly British, municipalities enjoy a local civil service very different from and more efficient than ours, and vastly better fitted for the assumption and discharge of expanding municipal functions.

As contrasted with American municipal service, that abroad is less political and more business-like in its character, more certain in its tenure, more continuous in its service, and more disinterested in its activities. Its desirable features are not only secured and protected by law, but are demanded by public sentiment. While the raw material is perhaps as good or better in the United States than in the European cities, it is handicapped in its efficiency by its political character and the uncertainty of its tenure. The American municipal servant never knows how long he is to be permitted to hold his place, and is subject to constant changes in policy and supervision. The only thing he can be reasonably sure of is that his head will ultimately drop into the basket. This system—for system it has come to be—may perhaps prevent dry rot and some of the evils of bureaucracy, but it is at the expense of efficient public service.

And this difference in political conditions and resulting municipal administration of public utilities is one which is fixed and incapable of change, except after the lapse of a long period, of which there is as yet no signs of a beginning. While British public sentiment would not tolerate political partisanship in municipal administration, with its consequent bad results, our own people have been too long and too thoroughly imbued with the virus of the doctrine that "to the victors belong the spoils" to make it possible at present to substitute efficiency in political municipal administration for the wasteful system and extravagant practices which now prevail. And it is not a matter of laws, or of civil-service regulations; the conditions I refer to are inherent in the fibre of the body politic. Perhaps the time will come—and every good citizen will pray Heaven to speed the time—when conditions will change here for the better in the particular referred to. But until they do, the part of wisdom is to restrict our municipal activities to their present limits.

So far as British municipalities have been successful in the prosecution of public utility enterprises other than those of a restricted character, it has been owing to the stability, the continuity, the business efficiency, and the lack of political activity of both the legislative and executive branches of their governments. The most responsible and experienced citizens are proud to serve as members of their town and city councils, and their constituents are glad to retain them in office as long as they will serve.

In the Manchester city council, for example, there is one alderman who, if he has not died since last summer, has served continuously for fifty years; another for forty years; another for thirty-eight years; ten others between twenty and thirty years; four others between seventeen and twenty years, and eight others for more than fifteen years. And such a showing is not exceptional. In Glasgow, for example, one city councillor has served twenty-eight years, another twenty-six years, another twenty-two years, and three others twenty-one years each. Six have served for twenty years, four between fifteen and twenty years, seventeen between five and fifteen years, and only twenty-nine out of the seventy-seven have come in as new members within the last five years. At least twenty-two, or one-third, of them each have premises in the city of a yearly rental value of more than $2000, presumably equivalent to a capital valuation of considerably more than $20,000.

"Graft" is unknown in British municipal assemblies. So far from the city fathers being the chief beneficiaries, directly or through others, of municipal expenditures, the holding of a single share of stock of the par value of five dollars in a company doing business with the city cost one councillor his seat, while in another city three members of the council were compelled to resign upon its becoming known that they were directors in a corporation which had dealt with the city to the aggregate amount of about $150 in three years.

And these are but sample illustrations of the jealousy with which the British city and town governments guard their reputations, which, like Caesar's wife, must be above suspicion.

The administrative officials appointed and retained in place by such legislative bodies necessarily partake in a marked degree of the high character of their superiors, with the result that their services are of the efficient and non-political character already indicated.

No general indictment of the town and city officials of the United States is necessary to justify the conclusion that our British brethren have far surpassed us in the character and efficiency of their municipal administrations. We are forced to confess, in sorrow rather than in anger, that the American experiment in self-government, as successful as it has been in other directions, has been a lamentable failure when worked out in our cities. Waiving the consideration that good citizens hesitate to subject themselves and their families to the awful ordeal of the fierce political contests that are almost always waged for local offices, their official tenure is too short and too uncertain to give them that thorough acquaintance with the complexity of municipal questions and machinery necessary to qualify them as the experts they ought to be. As soon as they begin to acquire that knowledge they are replaced by other candidates who have no "records" to handicap them and not enough public spirit to deter them from replacing better or more experienced men. The administrative officials of such a system, however capable by nature or efficient by experience, must necessarily suffer from service in it. The result is the presence among them of political activity in abundance, at the expense of business efficiency and effective public service. Neither branch of our city governments is therefore as well fitted as are British municipal legislative and

administrative officials to take on increased responsibilities in the form of enlarged municipal activities. When the administration of the departments now in charge of our local public officials show better results in economy and efficiency, it will be time, and not until then, to consider an enlargement of their responsibilities.

But the inquiry is in order whether, notwithstanding the superior character and efficiency of British municipal administration, the experiment of municipal ownership and operation of public utilities has been unqualifiedly successful in that country. Time does not permit, and perhaps the occasion does not warrant, a careful or detailed statement of the particulars in which municipal ownership in Great Britain can be reasonably claimed to be a failure. A brief statement without argument must suffice.

In the first place, it certainly has not resulted in any great financial profit. Official returns for the electric lighting undertakings of the Kingdom to December 31, 1904, show that less than fifty-eight per cent of 182 municipal undertakings showed a profit, which averaged only about $4000 for each undertaking, while ninety-two per cent of sixty-six private enterprises showed a profit, amounting on an average to more than $45,000 for each plant. And such profits as have been shown by the municipal undertakings seem to be arrived at as a result of the nearly total disregard of the items of depreciation and reserve. Sir Henry Fowler's "Returns" to the House of Commons show that in recent years the annual allowances for depreciation in the case of 193 water-works, 97 gas-works, 102 electric plants, and 29 tramways, owned and operated by municipalities in England and Wales, have averaged *less than two-tenths of one per cent* on the amount of capital originally invested, and barely more than two-tenths of one per cent on the balance of capital indebtedness remaining after payments of capital out of earnings. Profits, when realized, are generally not more than two or three per cent on the investment, the net result being an average loss upon the whole.

But to my mind the financial results are by no means the most satisfactory tests of the success or failure of municipal supply. If in all other important respects the results were favorable, a small profit or even an average loss might not condemn the enterprises. But when we find that whatever success has

been attained has been accompanied with other results of the most baneful character, it may be well claimed that, as was recently said by the *London Standard,* one of the most responsible of English journals, "Municipal trading is a thing which, except in very rare instances, stands self-condemned."

We may admit for the purpose of the discussion, what upon all the evidence I am inclined to think is the fact, that in the supply of gas and electricity for lighting the municipalities of Great Britain show a slightly better record as to the cost to the consumer than do the private companies. This is, however, amply accounted for by the differences of conditions, legal and otherwise, under which they operate, and by the fact that most of the principal undertakings are in the hands of public authorities. With respect to electric lighting, with the exception of Metropolitan London, practically all the private plants are in very small cities, while the great bulk of the municipal plants are in larger places.

That private enterprise can accomplish as good or better results than the public authorities in the field of electric light and power, even in England, is amply demonstrated by the results in the cases (which are very few) where private enterprise has been allowed to operate under substantially the same legal conditions as the public plants. In Newcastle-on-Tyne, for example, there is a private company operating free from the restrictions and limitations that surround and handicap almost all of the other private British enterprises of like character, which, when compared with important municipal undertakings, far outstrips them in the number of its customers, the number of lights supplied, the capacity in horse-power of motors, the number of kilowatt-hours sold, as well as in the cheapness of the price at which the current is supplied. The same city furnishes a striking illustration of the same fact as developed in the telephone industry. In that city is located the largest governmental telephone exchange in the country, but on July 31, 1905, it had only 550 subscribers, while the private company operating telephones in that city had over 9000 instruments installed.

Perhaps the most striking exhibition of the difference between the results of private and municipal enterprise is shown in the only five cities in Great Britain in which there is competition in the telephone business between the municipality and a private

company. The excess of private telephones over municipal telephones in Glasgow is 82 per cent; in Hull, 225 per cent; in Brighton, 67 per cent; in Portsmouth, 33 per cent; and in Swansea, 95 per cent—an average excess of more than 87 per cent. On December 31, 1905, the number of municipal telephones in the five cities named was less than 20,000, while the number of private telephones in the same areas was more than 40,000—an excess of 102 per cent. During the year 1905 the increase in municipal telephones was 12.2 per cent, and in private telephones 92 per cent.

If tested by the indisputably sound economic proposition that the character of a public service is to be judged of by its extent quite as much as by its cost, British municipalities have woefully failed in the experiment of furnishing artificial light and power to their inhabitants. The five Scotch and English cities of Glasgow, Edinburgh, Manchester, Leeds and Birmingham combined have a smaller number of lamps installed than the single city of Chicago, not more than half as many as Manhattan and Bronx districts of the city of New York, and barely more than the city of Boston; while their combined populations are considerably in excess of that of the New York boroughs named, about a million more than that of Chicago, and five times more than that of Boston. If, as is indisputable, it is better service to supply 100,000 people in a given area with gas or electric light at a given price per unit than to supply half that number of people at half the price assumed, the British municipalities can lay no claim to success in the exploitation and prosecution of the business of public lighting.

But in one respect municipal ownership in Great Britain has been worse than a failure—it has been a calamity. Owing to the restrictive character of the laws, particularly the Electric Lighting Acts of 1882 and 1886 and the Tramways Act of 1870, the electrical industry in Great Britain has been hampered and restricted to such an extent as to make the showing lamentable. So serious had this become in 1902 that the council of the Institution of Electrical Engineers of England appointed a committee "to determine whether they can recommend the council to take any action and if so, what action, that would assist the industry." After a most elaborate investigation and the taking of much testimony, the committee of the council resolved: "That notwith-

standing that our countrymen have been among the first in inventive genius in electrical science, its development in the United Kingdom is in a backward condition, as compared with other countries, in respect of practical application to the industrial and social requirements of the nation." And this result was attributable principally to the operation of laws expressly designed to encourage municipal and discourage private enterprise. The committee of the council of the Institution of Electrical Engineers expressly attributed the unsatisfactory results to what they denominate "the restrictive character of the legislation governing the initiation and development of electric power and traction undertakings and the powers of obstruction granted to local authorities," which they alleged to be the "essential difference between the electrical industry as it exists in the United Kingdom and as it exists abroad."

Without pausing to refer to the enormous increase of municipal debts and taxes, or the great augmentation of the army of municipal employees, which have attended the development of municipal ownership in Great Britain, and have led many of its most thoughtful and practical citizens to regret the extent to which the practice has been carried and to attempt to restrict its further development, sufficient otherwise appears to justify the conclusion that so far as municipal ownership and operation have been successful in Great Britain that success has not been of such a character as to justify its being used as an argument for the trying of the experiment in this country.

Having attempted to state the origin, meaning and present status of the agitation for municipal ownership of public utilities in this country, I will endeavor in the few minutes left at my disposal to give in outline my idea as to the proper treatment of it.

The remedy for existing conditions must come both from within and from without. The companies interested, the public authorities and the public at large must each contribute to the solution of the problem. None of them can or will be wholly effective without the others. Human nature is such that it can not be wholly trusted to regenerate itself, public clamor is frequently ineffective, while enactments of the legislature can not accomplish all that is desired.

In the first place, the companies engaged in furnishing public services must, in their own interest, strive more and more to

give good service at fair rates. While they can not all avail themselves of the advantages of legal so-called "sliding scales," they can hope for the best results only along the line of the theory of the sliding scale. In my judgment, the time has gone by, if it ever was, when extortionate rates and wretched service will promote the interests of the corporations. *He who serves the public best serves his company best.* Patience, a spirit of conciliation, and a real desire to increase facilities and reduce charges as rapidly as consistent with sound management, will ultimately bring their rewards in the form of increased earnings and larger dividends. And when the public in any given community comes to see that, notwithstanding the mouthings of the demagogues and the agitator, it is being fairly treated by the corporations, its objections to large and increasing returns upon invested capital will gradually disappear.

Next: The abuses of great wealth and corporate privileges to which I have alluded must cease, or at least be greatly limited. Self-interest must realize the fatality of a continuance of the abuses involved in gross over-capitalization, poor service, high prices, discriminations among consumers, and above all the attempt to control the lawmaking power for purely selfish ends.

I do not include among these objectionable practices that reasonable inflation of capital necessary to induce men to start new enterprises where, to offset the chances of loss, the possible amount of profits may reasonably be increased over that from ordinary investments. For such an inflation we have the warrant of the Supreme Court of the United States and a recent statement by President Eliot of Harvard that much can be said in defense of it. The difference between such an inflation of new capital and the objectionable stock-watering to which I have referred needs no elaboration.

To insist upon the inviolability of private property, the freedom to contract or not contract with any man or set of men, the full rewards of individual initiative and personal endeavor and fair treatment for capital invested in corporate enterprises, is not only permissible but imperative; but to ignore the rights of others, to fail to recognize reciprocal obligations, to show a reckless disregard or contemptuous indifference for public sentiment, is as unwise as it is discreditable. Capital must realize that there is a power greater than itself—the law; and that it is

amenable to a court more powerful than those constituted by statute—that of public opinion. I grant you it is often blind and unreasonable; if so, it must be educated and persuaded, not bullied or disregarded. While the agitator, the demagogue, the yellow journal, and the other pestilential agencies which constantly assail corporate enterprises must not be cajoled or tolerated, much less deferred to, "a decent respect to the opinions of mankind" is as fitting and as expedient in the business of the twentieth century as it was in the statecraft which evolved our immortal declaration of political independence.

Third: Public sentiment must be cultivated. The one great need in the economic world, as I view it, is popular education along sound economic lines. Let us no longer leave the exploitation of vital economic principles to the visionary or the doctrinaire, on the one hand, or to the irresponsible politician or selfish agitator, on the other. A real *Campaign of Education* is what is needed—a broad, comprehensive, intelligent, persistent, aggressive and well-directed campaign, which shall leave nothing in reason undone to spread sound economic doctrines. So far as self-interest enters into it, let it be an enlightened self-interest, having in mind the rights of all; let it be devoted to the fundamental proposition that all members of the community are bound together in such intimacy of relation that no member can ruthlessly injure another without ultimately feeling the recoil upon himself. "Live and let live," should be the motto.

Such associations as this can contribute greatly to a consummation so devoutly to be wished. I need not suggest the ways and means to you who are so much more familiar with them than am I.

State associations also can do much—particularly if imbued with a common purpose and subscribing to a common doctrine.

Time does not permit of the development of the suggestion; indeed, that would require perhaps as much time as I have already occupied; but serious attention to it would, in my judgment, go far to achieve the results so much to be desired.

But, as I have said, too much can not be expected from within. Human nature and human greed are such as to defeat the best intentions. At any rate, recent events in Washington have shown, if the assertion needed any verification, that the public will have a part, and a conspicuous part, in the attempt to

bring about more satisfactory relations between public-service corporations and the communities they serve. The only question is, what form and direction will these efforts of the public take? The answer to that question depends, in my judgment, very largely upon the wisdom or folly of those who have the control of corporate enterprises.

Just now the general tendency of the public seems to be to attempt to bring about improved conditions through the instrumentality of public ownership. I have attempted, though inadequately, to show that the experiment of public ownership, so far as it has been tried under conditions best calculated for its success, has not produced results which encourage the belief that it offers a panacea for the ills complained of. On the contrary, it has been shown to involve results so detrimental as to more than offset the advantages claimed for it. And yet the community may turn to it, even with a knowledge of its insufficiency, as a choice of evils. If it acts on that ground, it will be largely the fault of the corporations.

But, except as a choice of necessary evils, municipal ownership has no standing in the court of economics. It not only is not sufficient in itself to effect the results desired, but it is not the best means that can be employed for that purpose. I will venture in closing to suggest a much better one, from every point of view.

Public Supervision and Control of private public-service corporations, both in theory and practice, offers the best solution of the problem. It preserves the invaluable results of individual initiative—what Sir Richard Webster well termed "the absolute necessity of inventive competition." It does not discourage personal enterprise and the combination of private capitals. It leaves the American theory of industrial freedom unharmed, but controls it so far as the public interests require. It enforces the rights of the consumer and the general public, while recognizing the inviolability of private property and the inalienable right of the individual to industrial liberty. When nicely adjusted to the conditions to be dealt with, it operates to the advantage of all parties concerned—the consumer, the corporation and the general public.

Of course, this suggestion requires deliberate and ample consideration and elaboration—wholly impracticable at the end of a

paper already too ample in its proportions. But, at least, a concrete illustration, and what I claim to be a demonstration, of the soundness of the theory of public control of quasi-public corporations when applied in practice, may here be given.

The state of Massachusetts has for twelve years been trying the experiment. It has developed a most complete system of public control of gas, electric lighting, railroad, street railway and other public-service corporations, and has just added the telephone industry to the others—the only one heretofore omitted.

While there are imperfections in the system, while both the corporations and the public are at times restive and dissatisfied with the application of it in specific cases, it has, in my belief, upon the whole, been an advantage to all concerned. It is by no means perfect; it might easily be made intolerable. But the sober sense of the people of Massachusetts, as represented in their legislative assembly, has prevented any gross perversions of its objects or confiscatory applications of its principles. The public is better and more cheaply served; the capital employed is more amply protected; the relations of producer and consumer are more satisfactory, than is the case in most if not all other portions of the country. The evils of stock-watering have been eliminated or minimized, while reasonable returns upon legitimate investments have been assured, if earned.

Such laws, unwisely framed or viciously applied, could do an immense amount of damage; but in the older of our communities, certainly, where the people at large are to be credited with a reasonable degree of intelligence and a real desire to secure a "square deal" for all alike, it offers, in my opinion, a vastly better solution of existing difficulties than does municipal ownership.

Mr. Ingalls: Mr. President, I move that a rising vote of thanks be given Mr. Burdett for his very excellent address.

(The motion was unanimously carried by the entire audience rising.)

Mr. Martin: Mr. Burdett, I have great pleasure in declaring the motion unanimously carried.

ORDER OF BUSINESS

FRIDAY, June 8, 1906

MORNING SESSION, 10.20 A. M.

1. Paper—"New Illuminants." By H. E. CLIFFORD
2. Paper—"Higher-Efficiency Lamps—Their Value and Effect on Central-Station Service." By FRANCIS W. WILLCOX
3. Paper—"The Edison System of Southern California." By R. H. BALLARD
4. Paper—"Design and Manufacture of Hydro-Electric Installations." By E. F. CASSEL
5. Report—Committee on President's Address. SAMUEL SCOVIL, Chairman
6. *Question Box*. PAUL LÜPKE, Editor

EXECUTIVE SESSION

1. Election of Officers
2. Report of Treasurer
3. Amendment to Constitution

SEVENTH SESSION

The meeting was called to order at twenty minutes after ten o'clock by the president, and the first order of business was announced to be the paper on *New Illuminants*, by Professor H. E. Clifford, of the Massachusetts Institute of Technology.

The paper was presented by Mr. Clifford, as follows:

NEW ILLUMINANTS

The most striking characteristic of the developments in electric lighting during recent years is the great stride which has been taken in the direction of increased efficiency. Nor is this increase confined to any one type of illuminant. Arc, incandescent and vapor lamp alike share in the production of more light with the same expenditure of energy. One can not but hope that this gain may be followed by a corresponding development in its application to the problems of illumination.

INCANDESCENT LAMPS

The General Electric Company has developed and placed on the market a new carbon-filament lamp, with a rated efficiency of 2.5 watts per candle and a life equal to that of the 3.1-watt lamp. It is manufactured in 20, 40, 50, 75 and 100-cp units, the 20-cp lamp taking, therefore, the same energy as the present 16-cp, 50-watt lamp. Series lamps are also offered, with the new filament.

The distribution curves for a GEM lamp giving 50 mean horizontal candle-power are shown in Figure 1. The shade referred to is of the Prismo Glass Pagoda type.

The tantalum lamp is now obtainable abroad for voltages from 50 to 110, with an efficiency of 2.2 watts per candle. The 110-volt, 2.2-watt, 14.5-cp lamp is said to have a life of from 800 to 1000 hours, often running, however, to 1500 or 2000 hours. A 22-cp, 110-volt lamp is stated to have an average efficiency of 1.85 watts with a life of 800 hours. The price of this lamp is still $1.00, or in quantity $0.80, each.

Osmium lamps with a guaranteed efficiency of 1.5 watts and a life of 500 hours are now advertised as for sale in England at a price of $1.50 each, or $1.00 each in quantities for the 25-cp units. The allowance for returned lamps is $0.12.

The Kuzel lamp, also making use of a metallic filament, has shown an efficiency of better than one watt, but although it is announced for 110 volts, tests have been published at no higher voltage than 32.

The results already achieved with osmium, tantalum, zirconium (to mention some of the metals which have been proposed as a substitute for the carbon filament in the incandescent lamp) have greatly stimulated research in this direction,

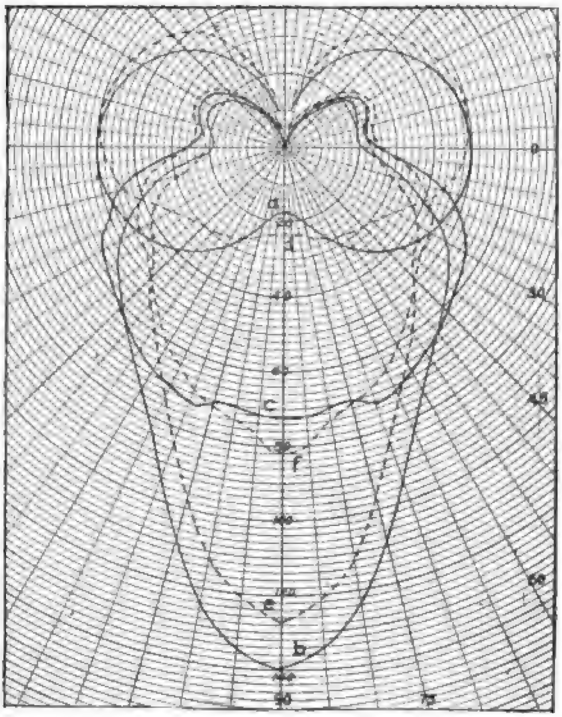


Fig. 1—The Average Candle-Power Distribution of Five 125-Watt, Two Loops in Series, GEM Lamps at Volts which Gave 50 Mean Horizontal Candle-Power

	Mean Spherical Candle-Power
a—Clear, without shade	40.66
b—Clear, with concentrating shade	34 53
c—Clear, with diffusing shade	36.28
d—Frosted, without shade	39.52
e—Frosted, with concentrating shade	32.02
f—Frosted, with diffusing shade	33.81

from which important results are almost certain to issue. Until, however, these metallic-filament lamps run equally well in all positions, give satisfactory service on both alternating and direct-current circuits, operate at commercial voltages, and can be manu-

factured at a much lower cost, the carbon-filament lamp, with reasonable rates for power and the development indicated by the recent gain in efficiency, will continue to maintain a supremacy it has long enjoyed.

NERNST SERIES STREET-LIGHTING SYSTEM

A development of some importance in connection with the Nernst lamp during the past year is the production of a series lamp for street illumination, of moderate candle-power, thus permitting the lamps to be used in cases where a fairly large number of small units is required. The outfit consists of a single-glower

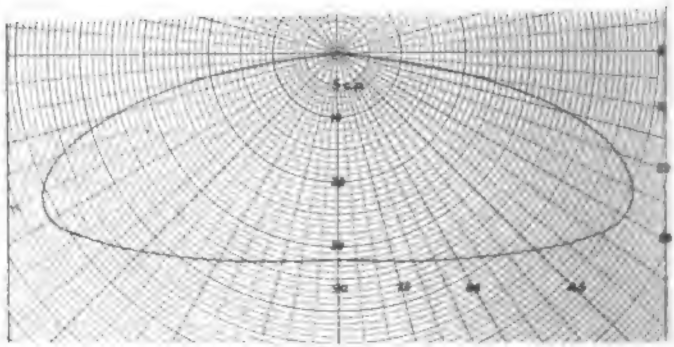


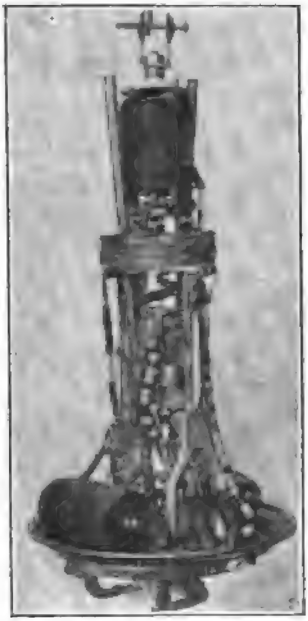
FIG. 2—NERNST SERIES LAMP. DISTRIBUTION OF LIGHT IN A VERTICAL PLANE

lamp connected with a series transformer, the primary coil of which is adapted for a circuit carrying 6.6 or 7.5 amperes constant alternating current. The lamp may, therefore, be used on any of the constant-current series systems and the ordinary 50-light tub transformer will operate about 200 lamps of the new series type. In this particular type the glower and heater are mounted in a vertical position on a porcelain base, and the heater is made in the form of the helix around the glower. The distribution is shown in the accompanying diagram, Figure 2, and is seen to be good for street-lighting purposes.

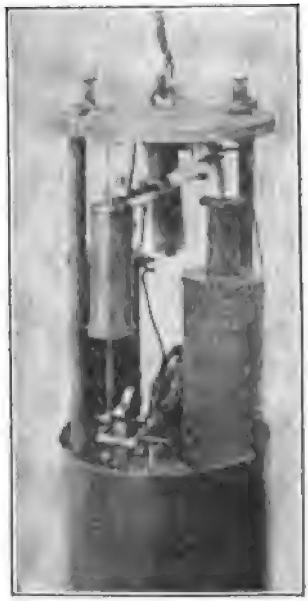
The watt consumption, including the auxiliary transformer, is about 115. The drop across the primary is 23 volts for a 7.5-ampere circuit, and 26 volts for a 6.6-ampere circuit.

LUMINOUS OR FLAME ARCS

It is only within a comparatively few years, and as a result of the scientific study of the arc, that it has come to be appreciated that the efficiency of such a light source is not dependent on temperature alone. The question of emissive power frequently plays an equal if not greater part in the determination of the ratio of watts to candle-power. It has long been realized that the light from the arc itself between pure carbon electrodes is of extremely



BREMER DIRECT-CURRENT, 9-AMPERE, MULTIPLE-CIRCUIT LAMP



BLONDEL DIRECT-CURRENT, 3-AMPERE, MULTIPLE, OPEN-ARC LAMP

FIG. 3

low intensity, and more than sixty years ago experiments were carried on in substituting other electrodes in place of pure carbon. No systematic investigation of the whole question took place, however, until the recent work of Bremer, Auer, Nernst, Blondel, Whitney, Steinmetz, to mention the more noted of the workers in this field.

This work has resulted in marked improvements in two directions: First, the production of a luminous arc between electrodes

whose rate of combustion is very much less than with ordinary carbons; and second, the evolution of the high-efficiency flame arc, in which the ordinary carbon electrodes are replaced by those

PHOTOMETRIC TEST OF BLONDEL ARC LAMP

LAMP EQUIPPED WITH LIGHT OPAL OUTER GLOBE—DIRECT-CURRENT, MULTIPLE-CIRCUIT

				Including Resistance		
Volts at terminals	45	45	50	55	55	55
Amperes	1.5	3	5	1.5	3	5
Watts at terminals	68	135	250	82.5	165	275
Hemispherical candle-power	134	368	868	134	388	868
Watts per hemispherical candle-power	0.57	0.345	0.289	0.615	0.425	0.317
Spherical candle-power	72	212	472	72	212	472
Watts per spherical candle-power	0.945	0.638	0.530	1.14	0.780	0.583

impregnated with metallic salts. Although these impregnated carbons are to-day manufactured in many forms differing in con-

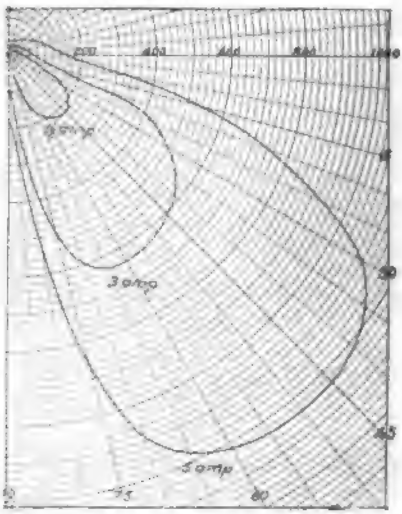


FIG. 4—BLONDEL LAMPS. DISTRIBUTION IN VERTICAL PLANE

structional detail, the purpose with all of them is to obtain a higher light efficiency. Up to the present time this gain in efficiency has been obtained at the expense of the life of the electrodes.

MAGNETITE LAMPS COMPARED WITH BREMER AND BLONDEL LAMPS

Photometric Tests

DISTRIBUTION OF LIGHT IN A VERTICAL PLANE

Blondel lamp equipped with light opal globe. Bremer lamp run without globe and with light opal globe. Magnetite lamp equipped with stationary electrode of copper, flat nickel-plated reflector and clear closed-base globe. Standard five-eighths-inch magnetite electrode.

	Bremer		Magnetite		Blondel
Globes	None	Opal	Clear	Clear	Opal
Volts at arc	41	41	80	80	46
Amperes	9.1	9.1	4	7	5
Watts at arc	372	372	320	560	226
Mean hemispherical candle-power	1811	968	368	992	868
Arc watts per mean hemispherical candle-power	0.205	0.384	0.870	0.565	0.260
Mean spherical candle-power	914	581	216	580	472
Arc watts per mean spherical candle-power	0.407	0.641	1 48	0.966	0.479

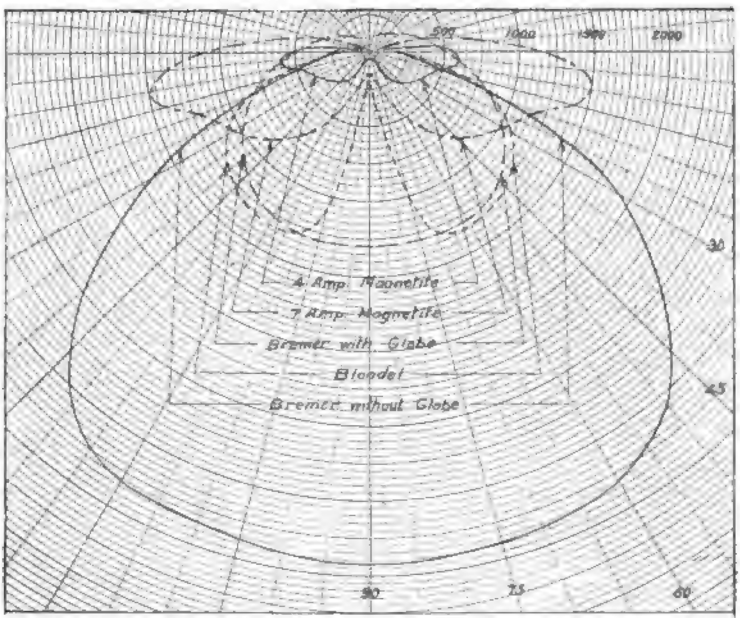


Fig. 5

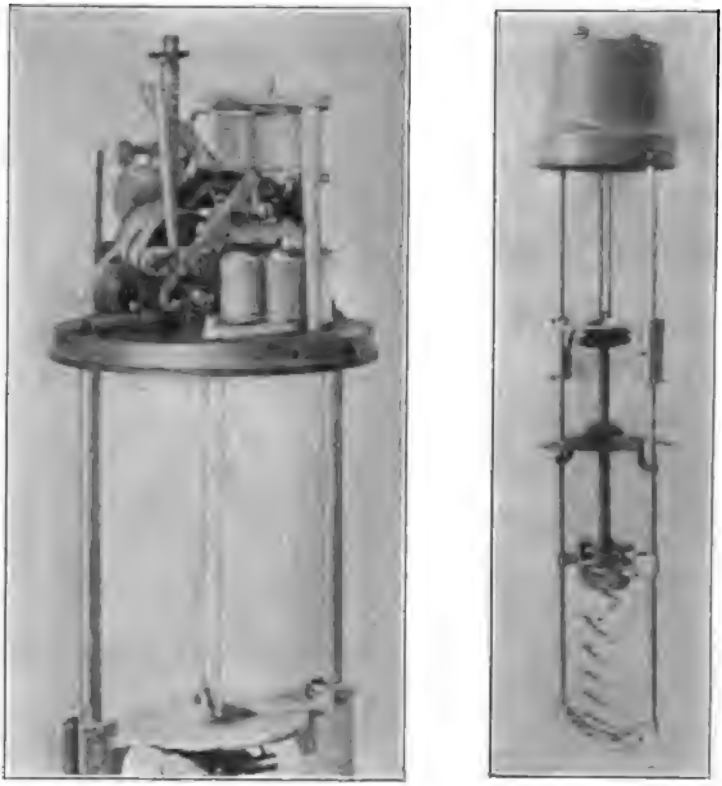


FIG. 6—SIEMENS-HALSKE ALTERNATING-CURRENT, 20-AMPERE, OPEN-ARC LAMP

FLAME ARC CARBONS

USED IN BAUSCH ARC LAMP—DIRECT-CURRENT, MULTIPLE-CIRCUIT

	ELECTRA		BREMER		CONRADTY	
	Opal Globe	Without Globe	Opal Globe	Without Globe	Opal Globe	Without Globe
Volts at arc	47	47	43	43	43	43
Amperes	8.2	8.2	9	9	9	9
Watts at arc	385	385	385	385	385	385
Hemispherical candle-power	370	585	798	1438	965	1870
Watts per hemispherical candle-power.	1.04	0.649	0.481	0.268	0.390	0.205
Spherical candle-power	200	293	475	719	559	935
Watts per spherical candle-power	1.93	1.30	0.81	0.536	0.688	0.410

RATIO OF MEAN SPHERICAL CANDLE-POWER

	Opal Globe	No Globe
Electra	1	1
Bremer	2.38	2.44
Conradty	2.80	3.19

The color of the light with these carbons is determined by the nature of the salts used and may therefore be controlled throughout a wide range. The efficiency, however, is very different for the different salts, the calcium compounds having given

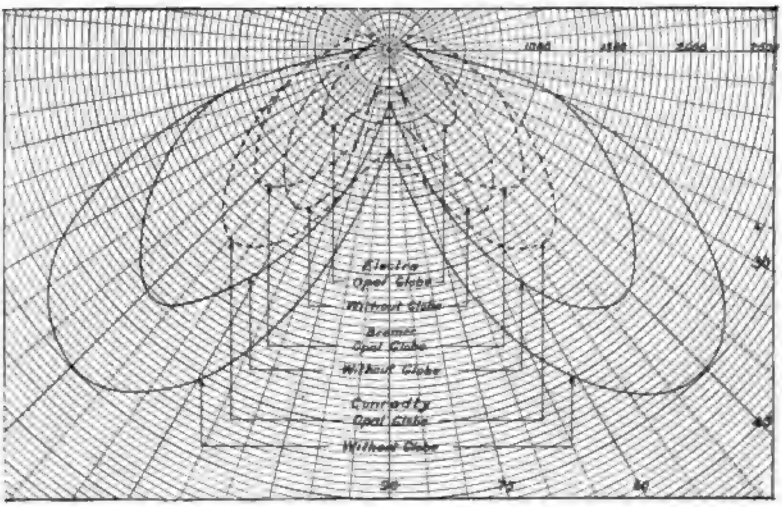


FIG. 7—FLAME ARC CARBONS. DISTRIBUTION IN A VERTICAL PLANE

the best results. This difference in efficiency is well illustrated by the curves of Figure 8, showing the distribution with flame carbons giving light designated as white, red and yellow, respectively. From the standpoint of efficiency the carbons producing yellow light are distinctly superior.

FLAME CARBONS

PHOTOMETRIC TESTS

SIEMENS-HALSKE ALTERNATING-CURRENT OPEN-ARC LAMP—WITHOUT GLOBE

Average Light Distribution in a Vertical Plane

	Terminals			Arc		
	White	Red	Yellow	White	Red	Yellow
Volts	34	34	34	32.5	32.5	32.5
Amperes	20	20	20	19.85	19.85	19.85
Watts	578	578	578	527	527	527
Hemispherical candle-power	963	1122	1614	963	1122	1614
Watts per hemispherical candle-power	0.601	0.515	0.358	0.547	0.470	0.327
Spherical candle-power	482	561	807	482	561	807
Watts per spherical candle-power	1.202	1.030	0.716	1.094	0.940	0.653

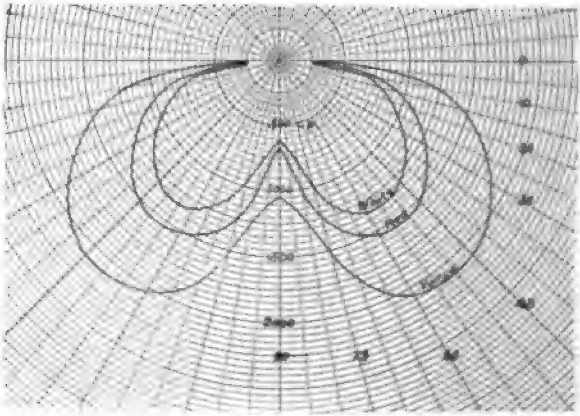


FIG. 8—FLAME CARBONS. DISTRIBUTION OF LIGHT IN VERTICAL PLANE

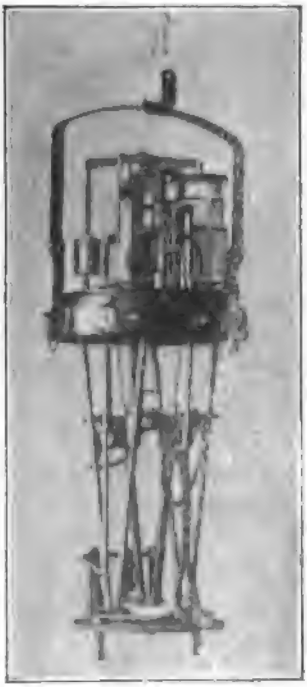


FIG. 9—SIEMENS DIRECT-CURRENT, 12-AMPERE, MULTIPLE-CIRCUIT LAMP

SIEMENS FLAMING ARC LAMP

12 AMPERES, DIRECT-CURRENT, MULTIPLE CIRCUIT—PHOTOMETRIC TEST

MEAN DISTRIBUTION OF LIGHT IN A VERTICAL PLANE

Carbons marked "Siemenskohle Effekt." Positive 10 mm., negative 9 mm.—yellow. Lamp equipped with light opal globe.

	Terminal	Arc
Volts	55	43
Amperes	12	11.85
Watts	660	510
Mean hemispherical candle-power	1283	1283
Watts per mean hemispherical candle-power	0.515	0.396
Mean spherical candle-power	752	752
Watts per mean spherical candle power	0.878	0.678

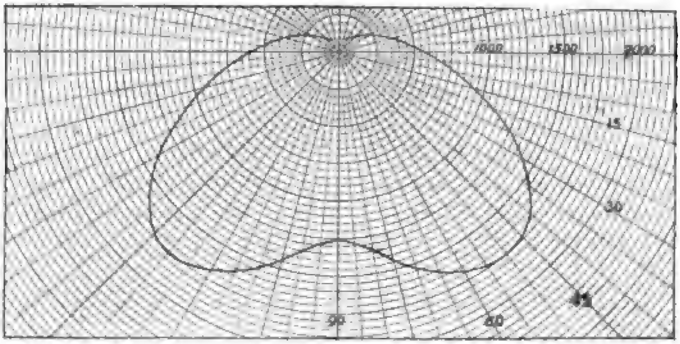


Fig. 10—Siemens 12-Ampere Lamp. Distribution in Vertical Plane

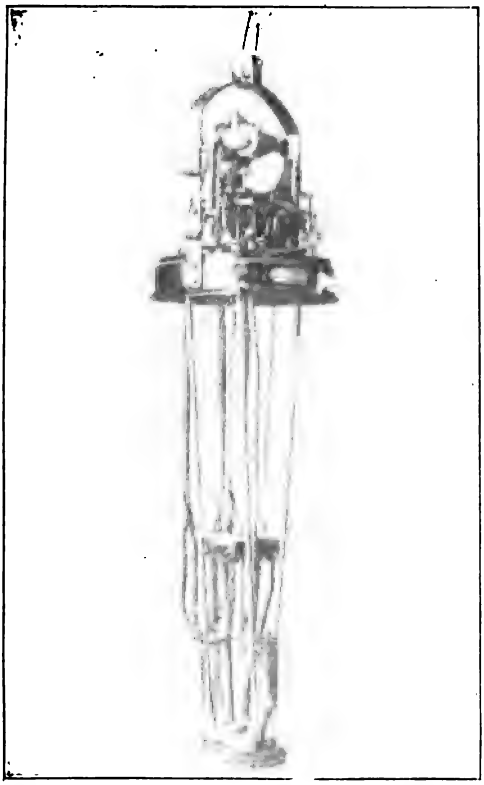


Fig. 11—Excello Direct-Current, 10-Ampere Lamp

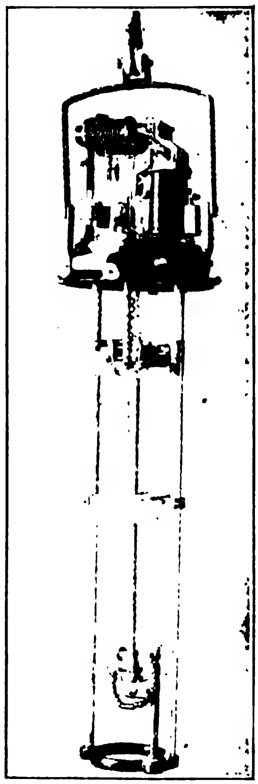


Fig. 12—Bausch Direct-Current, 9-Ampere, Open-Arc, Multiple-Circuit Lamp

An examination of the photometric curves, giving the distribution of light with and without globe, shows the importance of a careful study of the optical properties of the glass used, since

EXCELLO FLAME CARBON LAMP

10-AMPERE, DIRECT-CURRENT

READINGS TAKEN IN PLANE PERPENDICULAR TO PLANE OF CARBONS

	Arc		Including Resistance	
	With Globe	Without Globe	With Globe	Without Globe
Volts at terminals	49.3	46.3	55	55
Amperes	10	10	10	10
Watts at terminals	493	463	550	550
Mean hemispherical candle-power	1457	3029	1457	3029
Watts per hemispherical candle-power	0.339	0.153	0.378	0.181
Mean spherical candle-power	862	1695	862	1695
Watts per spherical candle-power	0.572	0.273	0.638	0.324

its selective absorption may bring about a considerable diminution of intensity for the very rays which are emitted by the arc. Such

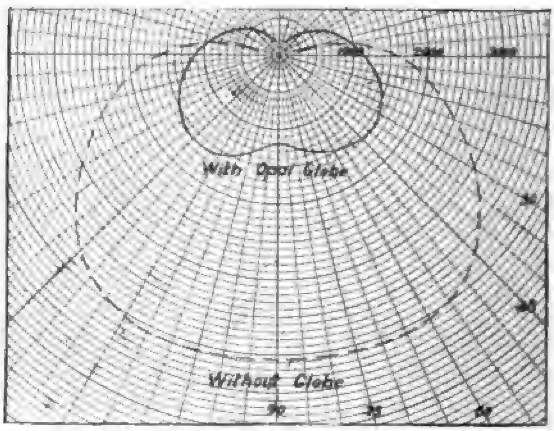


FIG. 13—EXCELLO LAMP. DISTRIBUTION IN VERTICAL PLANE

absorption evidently occurs with some of the lamps for which results are given.

In addition to the metallic salts for securing a longer and more brilliant arc, a flux is introduced to assist in the disposition of the slag formed. The presence of this slag makes it desirable

in some cases to place the carbons parallel or slightly inclined to each other, rather than in line. In lamps where this arrangement is adopted, a magnetic blower coil maintains a longer arc under ordinary conditions of operation, and acts in addition to prevent the arc frcm climbing up the sides of the carbons. In a number of flame arc lamps, however, the carbons are placed one directly above the other.

The diameter of the carbons used varies from 8 to 11 mm., the negative being as a rule 1 mm. less in diameter than the positive. The length varies from 325 to 600 mm., whereas the life ranges from 7.25 to 17.5 hours. Lamps are now manufactured having a magazine to contain eight or nine pairs of carbons, thus giving a much increased time of burning.

The production of fumes and the lack of steadiness have combined to render the flame arc lamp undesirable for interior illumination, although it is claimed for one of the most recent types that these objectionable features have been overcome.

For street lighting too large a proportion of the light falls near the vertical, although undoubtedly some reflector might be devised to remedy this defect, at least in part.

The illustrations of the mechanism and general arrangement of some of the flame arc lamps, together with the curves of light distribution, give a fairly good indication of the present state of the art.

VAPOR LIGHTING

It is well recognized, as a scientific principle, that the most efficient means for the transformation of electrical into light energy is electric conduction through rarefied gases or vapors. The practical application of this principle in one or another form has occupied engineers for some years past, and a most promising beginning in actual systems of this character has recently been made.

Under ordinary conditions an enclosed vapor, even though rarefied, offers an extremely high resistance to the passage of the electric current, but if the vapor be ionized it becomes a good conductor. The starting of the current through a vapor is thus a problem which does not exist with ordinary metallic conduction, and in this starting, and indeed thereafter, the cathode or negative electrode plays the significant part.

The current may be started either by bringing the two elec-

trodes together and then separating them, under moderate voltage, or by submitting the vapor to a high-voltage shock. In the latter case the conduction once started requires only a low voltage for its continuance, provided the direction of flow be not reversed. If, however, the electrodes reverse their sign, as is the case with alternating currents, the high-voltage shock must evidently be repeated with a rapidity determined by the frequency of the alternations.

The spectrum of the light emitted by luminous gases and vapors is not continuous, except for high density and temperature, but consists of bright lines whose number and color are characteristic of the gas or vapor. This makes it possible to control the color of the light to a degree, but also has its limitations in that a single vapor, admirable in other respects, may lack the desired color. In order to supply this deficiency a mixture of several vapors may, of course, be used for the conducting medium, but no one of the components must be of such a character as to attack the envelope which contains the mixture.

The envelope must not only be strong, durable and cheap, but it must be highly transparent and must not show selective absorption, at least for the particular wave lengths emitted by the vapor which it contains. It must be easily manipulated and worked. Glass tubing best fulfils these requirements, and although quartz has been suggested as a substitute, the efficiency obtained by its use has not equaled that for glass.

Vapor lighting commends itself on account of the low intrinsic brilliancy and consequent avoidance of retinal fatigue, and also from the standpoint of distribution, the diffusion obtainable being far more perfect than is possible with light sources of a point character. It is, of course, possible to have so perfect a diffusion that all contrast is eliminated, a result absolutely undesirable since it causes fatigue in the effort to judge the relative distances of objects within the field of view. The elimination of sharp, deep shadows, on the other hand, is certainly eminently desirable.

The Cooper Hewitt mercury vapor lamp and the Moore vacuum tube light represent the present day commercial systems of vapor lighting.

COOPER HEWITT MERCURY VAPOR LAMP

This type of lamp makes use of the vapor of mercury in an otherwise exhausted tube, and is now manufactured for both

direct and alternating current. Although the device of starting the lamp with a high-voltage shock has been used, the current is generally started by tilting the lamp, thus bringing the electrodes in contact through a stream of liquid mercury. The tilting may be done by hand or accomplished automatically. The light is limited in color by the fact that the spectrum of the vapor of mercury contains no red rays, and the lamp is useless, therefore, where accurate color comparison is essential. In its physiological effect it seems to be satisfactory.

Reference has already been made to the fact that the cathode or negative electrode is the significant factor in enclosed vapor lamps. A difficulty of some consequence in such lamps is the physical disintegration of this electrode brought about by the current; indeed, for currents of considerable magnitude it seems necessary that the cathode should be regenerative, that is, should be able to reconstruct itself on being disintegrated by the current. Mercury fulfils this condition most admirably.

The stability of operation has been shown to depend largely upon the wandering of the bright spot found at the negative electrode. Every lamp for a given impressed voltage has a mini-

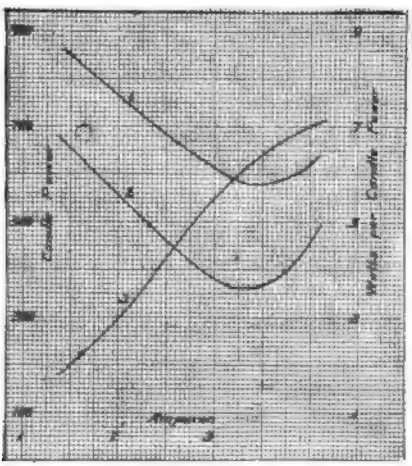


FIG. 14—COOPER HEWITT, H, LAMP

mum current below which the arc goes out. The magnitude of this current may be reduced by devices intended to prevent the wandering of the bright spot on the cathode, and also by the presence of inductance in the lamp circuit.

It is evident from the curves given in Figure 14 that the consumption of the lamp varies considerably as the current alters,

showing a well-marked minimum. This occurs for a current of about 3.5 amperes and gives the value at which the Cooper Hewitt lamps are ordinarily run. In Figure 14 Curves 1 and 2 show the relation of watt consumption to current for the lamp, including and excluding the auxiliary apparatus. Curve 3 gives the relation of candle-power and current. The lamp for which these results hold is a type H, direct-current form.

The direct-current, type K, lamp is intended to be run on a supply voltage of from 98 to 122 volts when installed singly, or from 196 to 244 volts when two lamps are installed in series. In this lamp the length of the light-giving tube is 45 inches, the candle-power rating 700, thus giving an efficiency of 0.55 watt per candle. The type H lamp is intended to be run on circuits of from 98 to 122 volts, two in series, or from 196 to 244 volts when four lamps in series are used. This lamp has a candle-power rating of 300, and when run two in series gives an efficiency of 0.64 watt per candle.

The alternating-current, type C, lamp makes use of the principle of the mercury rectifier in addition to the mercury vapor lamp, the current through the lighting tube being unidirectional. The lamp is started in precisely the same manner as the direct-current lamp, and consists, like the direct-current lamp, of tube, holder, reflector and auxiliary. Its efficiency is a maximum at about 3.5 amperes, at which it is rated. The lamp is intended to run on any frequency between 50 and 150, and on any commercial voltage. The power factor is about 80 to 85 per cent. The light-giving part of the tube is 28 inches long, giving 425 candle-power at an efficiency of about 0.65 watt per candle for 275 real watts and 325 apparent watts in the tube. The candle-power drops off gradually and reaches about 75 per cent of its initial value in 1000 hours.

If variations in line voltage occur, most of the variation will be taken up by the ballast, some by the series resistance, and the remainder by the lamp. This holds for lamps on both direct and alternating-current circuits. Thus for an increase of 10 volts on a 110-volt circuit, the current increases from 3.50 to 3.66 amperes. For a decrease of 10 volts, the current varies from 3.50 to 3.15 amperes.

It is important that the leads between the lamp and the auxiliary be short and straight, otherwise the lamp may go out,

due to the inductive action in these leads. The ballast is set at 3.5 amperes before leaving the factory, and works best at this particular setting.

Tubes are guaranteed to run one year at 12 hours per day, or approximately 4300 hours per year. The price of $12 for a new tube in this time makes the maintenance charges comparatively low.

The following table gives figures of the cost of the lamp and its maintenance, together with the current and watts consumed, and the candle-power:

TYPE K LAMP

104-VOLT CIRCUIT

	With Reflector	Without Reflector
Current	3.5 amps.	3.5 amps.
Average watts	364	364
Mean hemispherical candle-power	1200	575
Watts per candle hemispherical	0.303	0.63
Maintenance for 1000 hours in cents	279	279
Maintenance per kw-hr. in cents	0.767	0.767
Maintenance per kw-hr. per candle-power in cents	0.00064	0.00133
Maintenance per kw-hr. per candle-power-1000 hours in cents	0.64	1.33
Total cost of current per year at 5 cents per kw-hr. (4300 hours)	$78.26	$78.26
Cost of maintenance per year per lamp for 4300 hours	$12.00	$12.00
Combined current and maintenance cost per year per lamp	$90.26	$90.26
Combined current and maintenance cost per candle-power per year	7.5c.	15.7c.
Combined current, maintenance and initial cost per lamp first year	$125.26	$125.26
Combined current, maintenance and initial cost per candle-power first year	10.45c.	21.8c.

Attempts have been made to improve the color of the light of the mercury vapor lamp by the addition of the vapors of lithium, potassium and rubidium. These vapors, however, will attack the tube if made of quartz. Recently a patent has been granted to Mr. Hewitt for the introduction of inert gases, such as neon, nitrogen or argon, which are to be introduced to improve the quality of the light.

Various means, external to the lamp itself, have been suggested for improving the color of the light from the mercury vapor tube. Thus the use of fluorescent screens to supply the deficiency in the red rays has been proposed and rhodamine has

been tried, but with no very marked success. Undoubtedly, the best way of supplying what the mercury vapor lamp lacks in color is to use incandescent lamps, and these have been adopted in conjunction with this type of lamp in some cases with fairly successful results.

MOORE VACUUM TUBE LIGHTING

In the Moore system of vacuum tube lighting the ionization of the vapor is intermittent, rather than continuous, since alternating current is used. Thus the Moore lamp is a true alternating-current lamp, the electrodes reversing their sign at every alternation. It is necessary, therefore, that high voltage should be applied to the terminals of the lamp in order that the vapor may be broken down at each reversal of the current by a high-voltage shock. The frequency of these discharges through the tube must be such that the interval between successive discharges is not observed by the eye. A patent has been recently granted to Mr. Moore for automatically maintaining the vacuum at its proper value, thus preventing the rise in resistance which is so apt to take place in vacuum tubes.

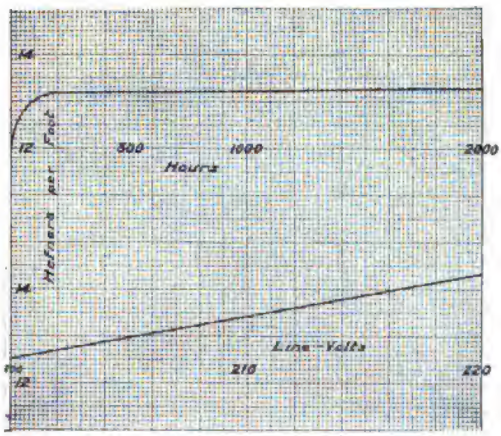
In the present "Moore Electric Daylight System" of illumination all of the distinctly electrical apparatus is placed in a single steel casing or box. A low-potential alternating-current circuit supplies the apparatus with 60-cycle current. From the box extends the tube used for illuminating purposes, which is, therefore, in the form of a loop and contains a non-metallic gas or vapor under very small pressure. The length of this tube can vary from a few feet to several hundred feet. The diameter of the tube can be changed as well as its shape, length, and the color of the light which it gives.

The terminals of the tube which are within the box contain carbon internal electrodes. This box also contains a step-up transformer, the high-potential terminals of which are attached directly to the tube electrodes and therefore never emerge from the sealed box, and the only wires extending into the box are the ordinary low-potential service wires. These boxes are fire-proof and since the glass tube extending throughout the area to be lighted is harmless to either life or property the system may be called a safe one. The long tube takes the place of the conduits, wire, sockets, lamps, *et cætera,* of the ordinary lighting system. The color of the light may be controlled by the character of the gas or vapor with which the tube is filled.

These long tubes are constructed on the premises by hermetically sealing together lengths of glass tubing each eight feet six inches long, by means of a new gas fire especially invented for the purpose. Mr. Moore has also worked out the other ingenious and necessary tools for doing this work rapidly, cheaply and in a manner that is thoroughly practical.

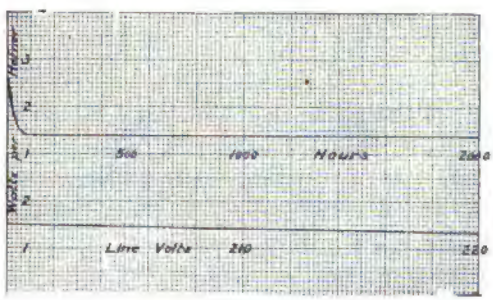
The relation among the different factors concerned in the Moore system is well shown by the following set of curves:

CURVE 1



CURVE 2

CURVE 3



CURVE 4

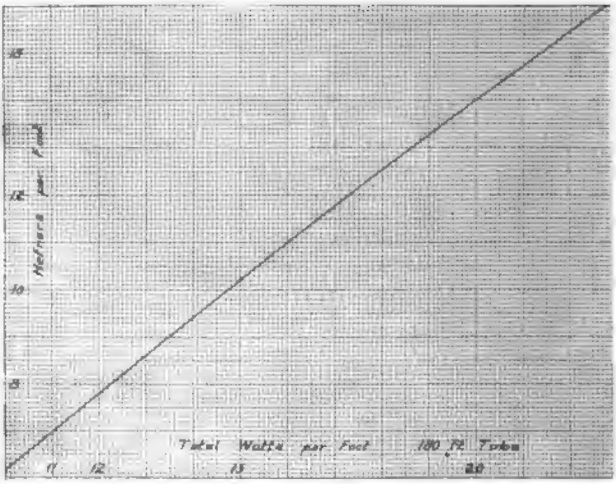
Curve 1 shows the relation of Hefners per foot to the time in hours. It indicates that the brilliancy of the tube automatically increases during the first 100 hours of its life and then remains

practically constant up to 2000 hours, which was the limit of the experiment on this particular tube.

Curve 2 shows the relation of the line voltage to the brilliancy and indicates that the relationship is practically linear in character. Hence variation in voltage on this system produces much less change in candle-power than with the incandescent lamp.

Curve 3 shows the relation of watts per Hefner to hours and is related with the increase in brilliancy with time shown in Curve 1. After the first 100 hours the efficiency is constant.

Curve 4 shows the relation of efficiency in watts per Hefner

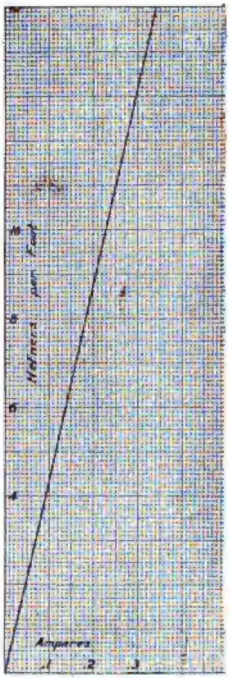


CURVE 5

to line voltage, indicating an increased efficiency as the line voltage increases. This increased efficiency, however, is very slight, showing that the tube has a practically constant efficiency over wide ranges of voltage. It is also to be remarked that the life of the tube is not dependent upon the voltage.

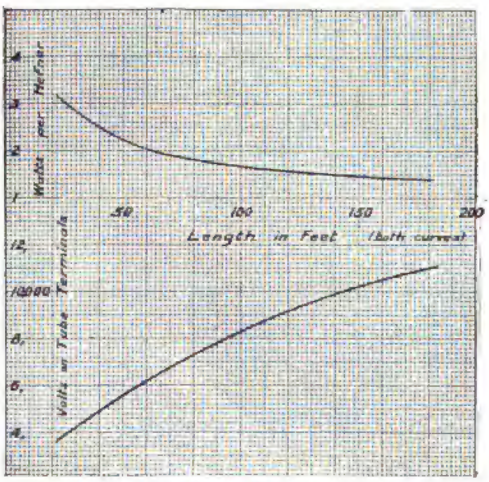
Curve 5 shows the relation of the brilliancy to the watts per foot of tube for a 180-foot tube, and indicates sensibly linear relationship.

Curve 6 shows the relation of the brilliancy expressed in Hefners per foot to the current through the tube and, as would



CURVE 6

CURVE 7



CURVE 8

be expected from what has already been shown for voltage and wattage, this relationship is also linear.

Curve 7 shows the increased efficiency which is obtained by increasing the length of the tube. For a 180-foot tube the efficiency is slightly less than 1.4 watts per Hefner.

Curve 8 shows the relation of voltage to length of tube, indi-

FIG. 15—TYPICAL INSTALLATION OF MOORE TUBE

cating that for the greater lengths of tube the voltage required does not increase as rapidly as the length of the tube itself.

Some typical installations of the Moore tube and also a view of a terminal box are shown in the accompanying reproductions from photographs. The first tube to be installed was in a photographic gallery in New York city in November, 1903, and this tube has been in continuous operation since that time. Great care is necessary in the selection of electrodes in order that they may

Fig. 16—Installation of Moore Tube

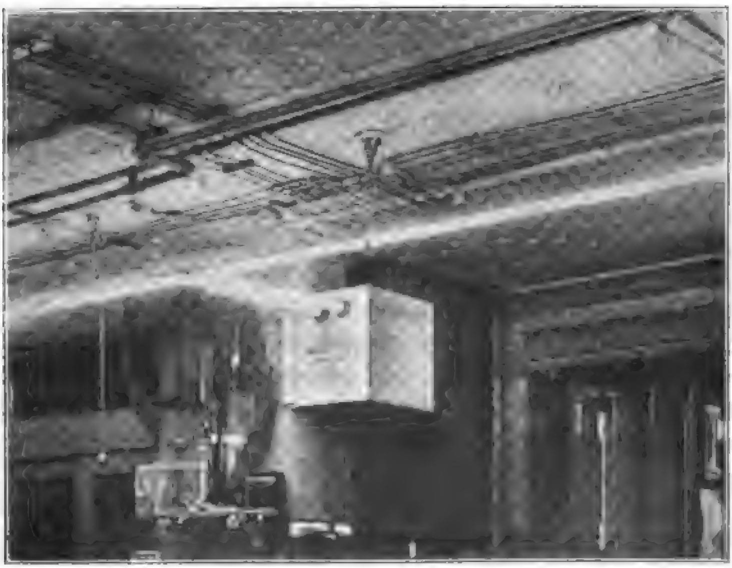


Fig. 17—View of Terminal Box (Moore Tube)

not disintegrate. In the tubes examined by the writer this darkening of the tube at the electrodes was evident in but one case. As yet, with the commercial limitations in the generation of high-voltage direct current, no direct-current tube has been developed for commercial use. There is, however, no inherent difficulty in the operation of such a tube. The most serious limitation of the Moore tube is the fact that it can not be economically used for small units, since each tube requires its special terminal box. In certain cases, also, the liability to fracture of the tube will render its use inadvisable. Its field is the illumination of large areas and in this it seems to have a promising future.

CONCLUSION

The concentration of effort in the securing of higher efficiency tends to make one lose sight of the danger of further increasing the intrinsic brilliancy, a danger all too plainly indicated in some of our modern illuminants. The last word in increased efficiency has not yet been spoken, but even so, the time seems ripe for greater devotion to questions of distribution.

DISCUSSION

PROFESSOR CLIFFORD: I fear I am but a poor advocate for the metallic-filament lamp in the present state of its development. The possibilities in this field are so great that we are inclined to lose sight of the limitations that exist at the present time. It is easy to speak of a one-watt or a 0.5-watt lamp, without realizing the really serious and extended effort that lies between us and such an accomplishment. There have been marked improvements in the development of metallic filaments, but the securing of a highly refractory metal that may at the same time be used to produce a highly coherent filament is at present a problem for future solution. That it will be ultimately solved, no one doubts, but how soon, it is unwise to predict.

What, then, are some of the limitations to the general use of the metallic-filament lamp? I may mention its inability to run in any position—and here I refer, of course, to the osmium lamp—the fact that many of the lamps are adapted to voltages much lower than those used in present practice, the inability to be

operated on both alternating and direct-current circuits, and the excessive cost.

That the tantalum lamp will not operate satisfactorily on alternating-current circuits has been suggested from time to time, but how serious this limitation is can best be appreciated by a study of the results of tests made for this association at the Electrical Testing Laboratories, of New York City, which are as follows:

LIFE TEST ON THIRTY TANTALUM LAMPS SUBMITTED BY AND TESTED FOR THE NATIONAL ELECTRIC LIGHT ASSOCIATION

The lamps were rated at 120 volts; fifteen of the clear-bulb type, fifteen of the frosted-bulb type. Each lot was divided into three groups of five lamps each, in such a manner that the average initial watts per mean spherical candle-power of the three groups constituting a lot was the same.

CONDITIONS OF TEST

One group of lamps from each lot was burned on a direct-current circuit, the current being obtained from a storage battery of large capacity. The second and third groups of lamps of each lot were burned on 133-cycle and 60-cycle alternating-current circuits, respectively.

The voltage was closely regulated. On the direct-current circuit, hand regulation was employed; on the alternating-current circuits, automatic regulation supplemented by hand control was used.

METHODS OF TEST

The lamps were burned at rated voltage and photometric measurements made at intervals throughout the test. They were handled with the greatest of care, but it was observed in the case of the 133-cycle test that even the most careful handling seemed deleterious to the life of the lamps. Therefore, these lamps were not removed from the racks after the 25-hour reading, and consequently photometric measurements could not be made. Certain of the 60-cycle and direct-current lamps were also allowed to remain on the racks without being photometered.

The numbers of these lamps, together with the period during which they were not photometered, are shown below.

RESULTS OF TEST

133-Cycle Test

Lamp No.	Mean Sph. Init. C. P.	Mean Sph. Init. W. P. C.	Mean Horiz. Init. C. P.	Mean Horiz. Init. W. P. C.	Reduction Factor	No. of Short-Circuits	Life to Burn Out (Hours)
			CLEAR-BULB LAMPS				
46	19.3	2.30	23.8	1.87	0.811	2	45
37	18.9	2.35	23.0	1.92	0.820	8	88 I-3
9	18.0	2.47	23.2	1.97	0.776	0	25
21	18.0	2.47	23.3	1.99	0.773	0	25
26	17.6	2.73	22.9	2.10	0.769	0	2
Avg.	18.4	2.46	23.2	1.97	0.789		37
			FROSTED-BULB LAMPS				
16	16.9	2.57	22.2	1.95	0.761	1 (See note)	99
23	16.8	2.70	22.4	2.03	0.750	1	39
32	16.4	2.71	22.1	2.01	0.742	0	25
47	17.5	2.58	23.8	1.90	0.735	0	40
29	18.1	2.56	23.8	1.94	0.761	0	25
Avg.	17.1	2.62	22.9	1.97	0.750		46

60-Cycle Test

Lamp No.	Mean Sph. Init. C. P.	Mean Sph. Init. W. P. C.	Mean Horiz. Init. C. P.	Mean Horiz. Init. W. P. C.	Reduction Factor	No. of Short-Circuits	Life to Burn Out (Hours)
			CLEAR-BULB LAMPS				
20	19.0	2.40	24.5	1.86	0.776	0	178
10	18.2	2.43	22.9	1.92	0.795	0	165
13	17.5	2.56	22.8	1.97	0.768	0	308
2	18.0	2.48	22.3	2.01	0.807	2	237
35	19.4	2.58	24.0	2.09	0.808	0	I-3
Avg.	18.4	2.49	23.3	1.97	0.790		178
			FROSTED-BULB LAMPS				
4	17.8	2.52	23.1	1.93	0.769	1 (See note)	2 I-2
6	16.4	2.70	21.6	2.05	0.758	0	5
*7	15.9	2.72	22.3	1.95	0.713	3	234
11	16.9	2.64	22.7	1.97	0.745	1	272
18	18.0	2.54	24.1	1.90	0.747	1	133
Avg.	17.0	2.62	22.7	1.96	0.746		129

* No photometric measurements between 36 hours and 217 hours.

NOTE—In the case of frosted lamps, excepting when the lamp actually goes out and is lighted up again, it is impossible to determine whether or not short-circuits occur in the filaments. The zeros in the column headed "No. of Short-Circuits" mean, therefore, that the lamp did not go out until the final burnout occurred.

DIRECT-CURRENT TEST

Clear Lamps

Lamp No.	Mean Sph. C. P. Init.	Mean Sph. C. P. Mean	Mean Sph. C. P. 510 H.	Mean Sph. C. P. % Dec.	Watts per M. S. C. P. Init.	Watts per M. S. C. P. Mean	Watts per M. S. C. P. 510 H.	Watts per M. S. C. P. % Inc.	Total Sph C. H.	Sph. Red. Factor Init.	Sph. Red. Factor 510 H.	Sph. Red. Factor % Dec.	M. H. C. P. Init.	M. H. C. P. 510 H.	Watts per M. H. C. P. Init.	Watts per M. H. C. P. 510 H.	Life to Burn Out (Hours)
22	18.8	10.7	..	..	2.43	4.24	..	..	597	0.780	..	..	24.1	..	1.89	..	56
19	17.8	19.4	‡20.0	—12.30	2.54	2.39	‡2.31	—9.0	9,466	0.766	‡0.892	+16.3	23.2	‡22.4	1.94	‡2.08	489
*38	18.4	†19.6	16.9	+ 7.63	2.48	†2.33	2.64	+6.3	†13,709	0.773	0.947	+22.8	23.8	17.9	1.92	2.52	..
41	19.4	23.9	‡21.9	—13.00	2.48	2.07	‡2.28	—8.1	9,657	0.802	‡0.948	+18.3	24.2	‡23.1	1.98	‡2.15	404
31	18.7	20.8	..	..	2.59	2.38	..	..	8,120	0.800	..	..	23.4	..	2.06	..	391
Avg.	18.6				2.51					0.784			23.7		1.96		

Frosted Lamps

Lamp No.	Mean Sph. C. P. Init.	Mean Sph. C. P. Mean	Mean Sph. C. P. 510 H.	Mean Sph. C. P. % Dec.	Watts per M. S. C. P. Init.	Watts per M. S. C. P. Mean	Watts per M. S. C. P. 510 H.	Watts per M. S. C. P. % Inc.	Total Sph C. H.	Sph. Red. Factor Init.	Sph. Red. Factor 510 H.	Sph. Red. Factor % Dec.	M. H. C. P. Init.	M. H. C. P. 510 H.	Watts per M. H. C. P. Init.	Watts per M. H. C. P. 510 H.	Life to Burn Out (Hours)
1	17.3	14.8	12.7	26.4	2.54	2.93	3.36	32.1	7,882	0.775	0.714	— 7.3	22.3	17.8	1.95	2.44	532
*8	18.1	16.0	12.5	30.9	2.50	2.83	3.50	40.0	9,720	0.767	0.806	+ 5.3	23.6	15.5	1.92	2.84	607
15	16.9	11.3	..	..	2.63	3.82	..	..	34	0.732	..	..	23.1	..	1.92	..	3
*40	15.6	11.5	6.6	57.6	2.78	3.66	6.13	120.6	6,987	0.726	0.943	+30.0	21.5	7.0	2.02	5.81	609
43	16.3	12.5	6.4	60.5	2.68	3.45	6.25	133.2	6,975	0.758	1.015	+34.2	21.5	6.3	2.01	6.24	557
Avg.	16.8	13.2	9.5		2.63	3.34	4.81		6,320	0.751	0.869		22.4	11.6	1.96	4.33	462

* No photometric measurements made between 101 hours and 510 hours.

The numbers indicated by † were computed up to 699 hours. This lamp still burning at 769 hours.

‡ Values at 226 hours.

MORTALITY TABLE

	D. C.		60 Cycles		133 Cycles	
	Clear	Frosted	Clear	Frosted	Clear	Frosted
Number of lamps......	5	5	5	5	5	5
First burnout.........	56 H.	3 H.	1-3 H.	2 1-2 H.	2 H.	25 H.
Sixty per cent burnout.	404	557	178	133	25	39
One hundred per cent burnout	*	609	308	272	88 1-3	99
Total hours of test....		609	308	272	88 1-3	99
Survivors at end......	1	0	0	0	0	0
Average life of group..		462	178	129	37	47

* One lamp still burning at 769 hours.

It should be noted that when rupture occurs in the filament of a tantalum lamp, it is sometimes possible to re-establish the circuit by tapping the lamp, thus causing the loosened end of the filament to make contact on an adjacent section, short-circuiting part of that section. This causes a decrease in resistance and a corresponding increase in current and candle-power.

During the test the lamps were frequently inspected and such ruptures as the above observed and recorded. The periods at which these ruptures were observed are indicated on the individual curves of the lamps, and are also shown in the tabulations below.

133-Cycle Test

CLEAR LAMPS

Lamp No.	First Rupt.	Second Rupt.	Third Rupt.	Fourth Rupt.	Fifth Rupt.	Final Rupt.
46	30	40	45	..	..	45
37	61	65	*85 3-4	..	..	88 1-3
9	25	..	..	..	..	25
21	25	..	..	..	..	25
26	2	..	..	..	..	2

FROSTED LAMPS

Lamp No.	First Rupt.	Second Rupt.	Third Rupt.	Fourth Rupt.	Fifth Rupt.	Final Rupt.
16	62	99	..	..	..	99
23	34	39	..	..	..	39
32	25	..	..	..	..	25
47	40	..	..	..	..	40
29	25	..	..	..	..	25

60-Cycle Test

CLEAR LAMPS

Lamp No.	First Rupt.	Second Rupt.	Third Rupt.	Fourth Rupt.	Fifth Rupt.	Final Rupt.
20	†178	..	..	..	..	178
10	165	..	..	..	..	165
13	308	..	..	..	..	308
2	168	178	237	..	..	237
35	1-3	..	..	..	..	1-3

FROSTED LAMPS

Lamp No.	First Rupt.	Second Rupt.	Third Rupt.	Fourth Rupt.	Fifth Rupt.	Final Rupt.
4	1-2	2 1-2	..	..	..	2 1-2
6	†5	..	..	..	..	5
7	142	190	220	234	..	234
11	260	272	..	..	..	272
18	93	133	..	..	..	133

Direct-Current Test

CLEAR LAMPS

Lamp No.	First Rupt.	Second Rupt.	Third Rupt.	Fourth Rupt.	Fifth Rupt.	Final Rupt.
19	476	480	484	488	489	489
22	‡9	‡14	‡56	..	..	56
38	768	..	..	..	..	768
41	226	377	404	..	..	404
31	226	351	375	379	391	391

FROSTED LAMPS

Lamp No.	First Rupt.	Second Rupt.	Third Rupt.	Fourth Rupt.	Fifth Rupt.	Final Rupt.
1	532	..	..	..	..	532
8	607	..	..	..	..	607
15	3	..	..	..	..	3
40	609	..	..	..	..	609
43	557	..	..	..	..	557

* The filament of lamp No. 37 was ruptured six times and was repaired by tapping between 85¾ hours and 88⅓ hours.

† Exploded.

‡ Filament loose at main anchor clamp. Taken off test at 56 hours, after repeated attempts to repair the filament by tapping the lamps.

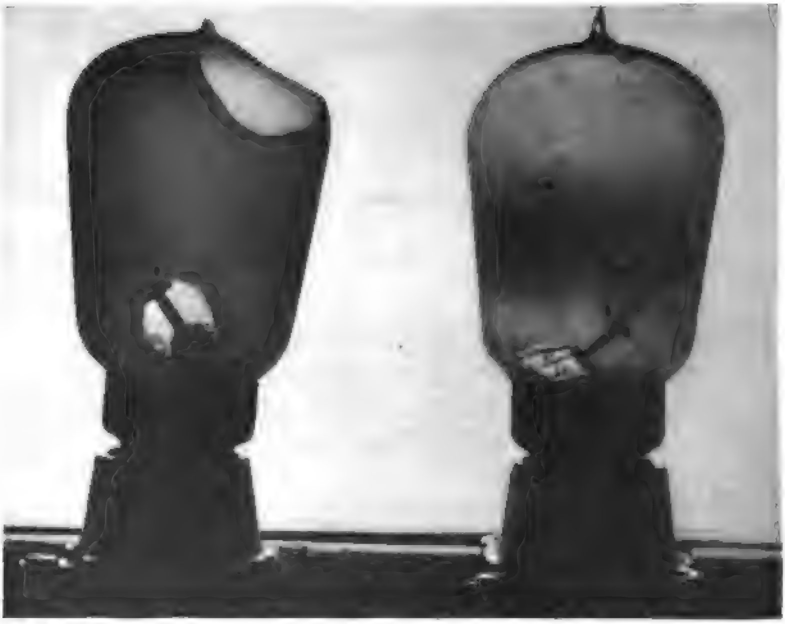
It should be noted that the greatest bulb discoloration occurs in a horizontal zone parallel to the vertical spires of the filament. As a result of this the mean horizontal candle-power decreases more rapidly than the mean spherical candle-power, causing the reduction factor to increase.

These results show conclusively that the tantalum lamp is at present absolutely without value for alternating-current circuits. Observe, also, that the maximum life on direct current with four of the five clear lamps was 489 hours, and with the five frosted lamps 609 hours. This certainly is very different from the 800 to 1200 hours about which we have heard so much. I can not but feel that the quality of the tantalum lamp to-day is not so good as in those that were first put on the market.

Now, if this is the case with the tantalum lamp, it seems to me that it is at present a doubtful expedient to replace carbon-filament lamps with tantalum lamps. I have not in mind the figures that show the relation of the total number of lamps used in alternating and direct-current service respectively, but my impression is that about four times as many lamps are used for alternating as for direct-current service annually in the United States. I fancy, also, that the number of central stations supply-

ing alternating current for lighting purposes is eight or ten times as great as that of those giving direct-current service.

Again, you are going away from what is very important in engineering work, namely, standardization. You must carry a greater variety of lamps, since tantalum lamps certainly can not be used on alternating-current circuits. I believe the cost is now given as 75 cents, and of course there will be the ordinary



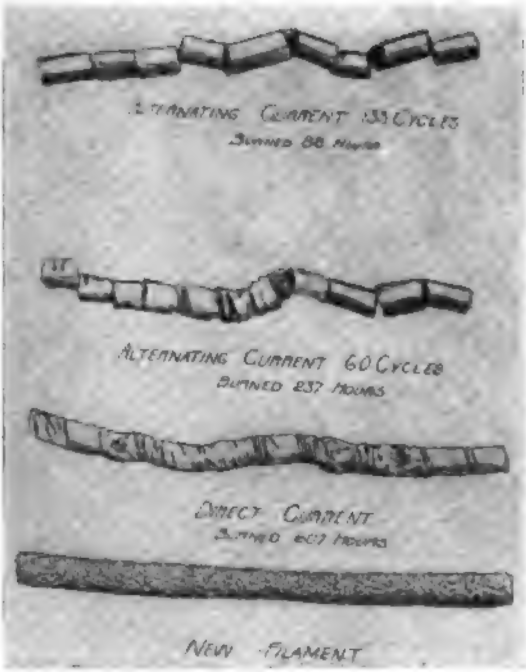
PHOTOGRAPH OF LAMPS THAT EXPLODED

LAMP NO. 6—BURNED ON 60 CYCLES, EXPLODED AT 5 HOURS LAMP NO. 20—BURNED ON 60 CYCLES, EXPLODED AT 178 HOURS

discounts from this figure. But if we put the first cost of the tantalum lamp at 60 cents and its life at 700 hours, then for a two-watt, 20-cp lamp the renewal charge is something over two cents per kilowatt-hour.

You may say, as has been suggested elsewhere, that the renewal charge may be placed on the customer. It seems to me that, in view of the delicacy of the situation existing between

the public-service corporation and the consumer, to tack anything more on the consumer would be fatal. The suggestion is made that we may draw an analogy from the situation existing when the Welsbach mantle was introduced by the gas companies. It seems to me that the analogy in this case is a most imperfect one, since the use of this mantle involved a considerable reduction in the consumption of gas and an increase of from 100 to 300

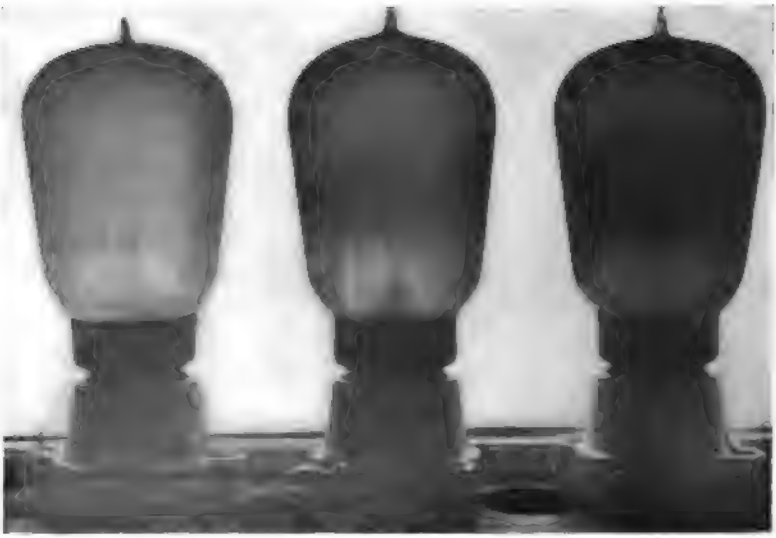


SKETCH OF FILAMENTS AS VIEWED UNDER THE MICROSCOPE, ILLUSTRATING THE EFFECT OF DIRECT CURRENT AND ALTERNATING CURRENTS

per cent in the amount of light. Then, too. the gas companies, until recently, at least, have not been in the habit of giving free renewals. Many of the central stations grant free renewals, and if you attempt to depart from that policy you at once offer a strong argument for public ownership of these quasi-public corporations.

There is another effect to be considered—a sort of psycho-

logical effect. You go to a man—as I have had occasion to do within the past year—and present a curve showing what he can gain with a high-efficiency, metallic-filament lamp, and tell him the lamp costs 75 cents. To put it mildly, the intensity of the language the man uses would make a flame arc look pale in comparison. Seventy-five cents for a lamp to a man who has been accustomed to pay 16 or 18 cents is simply a revolution, and the ordinary customer is not going to compare carefully the



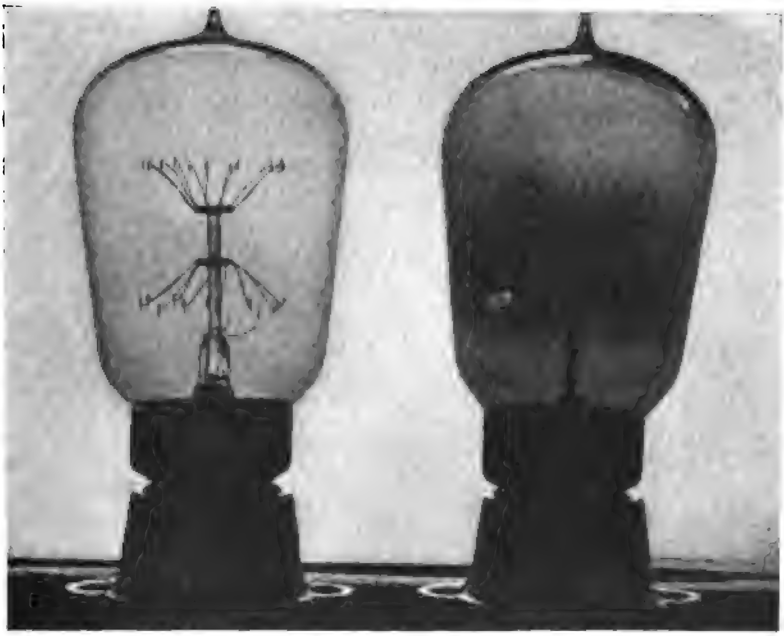
Photographs Illustrating Bulb Discoloration

Lamp No. 23—Burned 39 Hours on 133 Cycles

Lamp No. 43—Burned 557 Hours on Direct Current

candle-hours at which the curve of such a lamp crosses the ordinary incandescent-lamp curve. The thing at which he immediately looks in buying a lamp is the first cost. That is the thing that is nearest to him and it is the biggest thing to him. It seems to me that the effect of offering a high-cost lamp to the consumer in the present state of the development is most undesirable. I believe, also, that there are many small stations that can not afford free renewals of the tantalum lamp at its present price.

I take it we all aim to be progressive, but there is a great difference between being intelligently progressive and in chasing up every new development that offers itself, while in the transition period. There is no question that the concentrated effort now being made in the production of the highest efficiency metallic-filament lamp will result in something of real value—indeed, the tantalum lamp indicates that; but it seems to me an



NEW LAMP — LAMP NO. 19—BURNED 489 HOURS ON DIRECT CURRENT

unwise move to introduce the tantalum lamp at present, comparing two watts with 2.5 watts, 60 cents with 20 cents in price, and the cost of lamp renewals per kilowatt-hour.

In closing this subject, I want to urge strongly what appeals to me as a most important matter and one that is not ordinarily considered with the care that it seems to merit. I refer to the use of auxiliary devices for saving stray light. A good illustration of the successful use of such devices is offered in the accom-

panying diagram showing the distribution curves obtained on four-ampere and five-ampere magnetite arc lamps, equipped with flat nickel-plated reflectors.

MAGNETITE ARC LAMPS

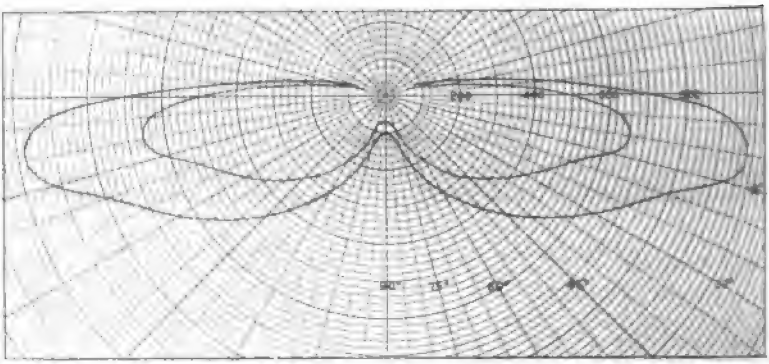
Photometric Tests

4 AND 5 AMPERES, 110 VOLTS DIRECT CURRENT, MULTIPLE CIRCUIT—MEAN DISTRIBUTION OF LIGHT IN A VERTICAL PLANE

Lamps equipped with clear closed-base globes, flat nickel-plated reflector and cylindrical copper anode.

	—Terminal—		—Arc—	
Volts	110	110	73	75
Amperes	4	5	4	5
Watts	440	550	292	375
Mean hemispherical candle-power	429	641	429	641
Watts per mean hemispherical candle-power	1.02	0.860	0.681	0.585
Mean spherical candle-power	244	364	244	364
Watts per mean spherical candle-power	1.80	1.50	1.20	1.03

No matter what the efficiency is, so far as the mere illuminant is concerned, there is coming a time when, it seems to me, further gain is to be obtained only by the use of stray light that is now allowed to waste itself in places where we do not particularly care for the illumination actually given. To



Magnetite Lamp—Distribution of Light in a Vertical Plane

bring about the placing of this stray light in the useful direction is quite as important, even in the present state of development, as the focusing of our attention wholly on the question of high-efficiency illuminants, neglecting the consideration of how we

may get a cheap illuminant by using light that we now throw away.

DISCUSSION

MR. D. MCFARLAN MOORE (Newark, N. J.): Professor Clifford has made a number of statements, giving you considerable data in reference to my latest system of vacuum-tube lighting. I say latest, because I know that many of you know that I have changed the form of my system of lighting almost yearly for twelve years past, but I believe that I can state positively that I have arrived; that the system I now have is of permanent value and of great importance to the electric-lighting industry. Professor Clifford also stated that he, personally, actually measured only one of my tubes in commercial operation. It is therefore my pleasure to request that a committee be appointed from this association to take advantage of the fact that I have a tube on this pier, and that the committee make accurate measurements and thereby corroborate Professor Clifford's statements.

I can not too strongly emphasize the fact that my tube lighting system, as it is now in operation in different parts of this country —in Newark, Pittsburgh, New York and Atlantic City—is of extreme importance. The actual watts per hefner of the tube, as you gentlemen saw it burning last night, is 1.18; I mean that is the efficiency of the tube as a light source, which is the way all other forms of illuminants are rated. However, if all the transformer and other losses are taken into account, the watts per candle-power of this particular tube to which I refer are 1.5. You will note by the curves presented that the efficiency varies somewhat with the length of the tube; the longer the tube, the more efficient it is. Therefore the watts per candle of the tube on this pier are 1.5. The actual total candle-power of this tube is 2200 and the total wattage 3300. The tube in this case supplants incandescent lamps, and all lamps that are used for lighting large areas will be supplanted by tubes. It is the largest field in the whole lighting industry. With 80 per cent of all the incandescent lamps in use to-day throughout the world used for lighting large areas, the great problem of electric lighting has been, and is, to produce a light that is suitable for lighting large areas and distributing the light in a manner that is really and truly compa-

rable to daylight. The actual saving in this tube, as it supplants these incandescent lights in this particular case, is about 15 per cent, but the tube is producing about 400 per cent more light than the incandescent lamps formerly did, and the actual watts per candle-power of the tube, as it is in operation here, is about 400 per cent better than the incandescent lamps that it displaced.

You have heard, gentlemen, a great deal about the metalized filament. From the best information obtainable, the increase in efficiency claimed for these new filaments is not more than 25 or 30 per cent. I boldly make the claim of an increase in efficiency for my system of between 300 and 400 per cent; and further than this, and of extreme importance, is the fact that the system as it now exists has a life that is indefinite. It seems rather radical to say that the tube will last forever, but it does not seem at all improbable when I tell you that the tube is simply burning air electrically, and that as long as there is atmosphere and as long as you central-station men furnish the current, the tube will continue to live without any renewals whatever. It is burning air instead of carbon. For years I struggled with the problem of finding a suitable gaseous conductor. All scientists now admit that light produced from a gaseous conductor will be the final form of illumination as distinguished from light produced by heated solid matter.

The next point of importance is the present commercial state of this new system of lighting. Thousands of feet of these tubes are now in commercial use, and none of them have given any trouble. Every foot of tube ever placed in use is still in use. So far as safety is concerned, this system is paramountly better than any other form of lighting ever devised. You will notice in the particular installation on this pier that all of the electrical apparatus is outside of the room in which the illumination is desired. Of course it could be placed inside, in a suitable wall pocket, but it is possible now to illuminate any area with practically no purely electrical apparatus within the area to be lighted. The tube itself is harmless to either life or property. It feels comparatively cool to the hand as compared with incandescent lamps, and could not set fire to anything.

Professor Clifford referred to breakage. It is true that if a tube of this kind is broken the light will simply be extinguished; but the actual length of time required to make a joint in one of

these tubes is about a minute, therefore a break is not at all serious. The very nature of the system is such that the liability of the tube being broken is extremely small. The fundamental idea is to place the tube out of reach, so that there is no chance of its being broken. In actual commercial use there has been no trouble on this score. Professor Clifford also referred to the fact that at the present time the tube is not suitable for small units. For extremely small units, I agree that it is not suitable; but a tube about 20 feet long can compete with ordinary incandescent-lamp systems in actual use.

MR. STEPHEN B. BURROWS (Brooklyn, N. Y.): I would ask a question regarding the color of the light. Is it possible to get a color anywhere nearer the color that is suitable to the eyes—a light that we should like to read under?

MR. MOORE: The best answer to that question is simply to refer to the tube on the pier, which you have seen; the diffusion of light is perfect. So far as its exact tint is concerned, I claim that it is an improvement over the incandescent light. A system of vacuum-tube lighting is now available for central-station men, the color factor of which is an improvement over the other lights used, because of the important fact that by changing the gas that is fed to the tube I am able to produce any color desired. One of the largest department stores in Newark is using a tube 150 feet long in which I have produced a light that is practically pure white; in fact, it is the same as daylight, in many respects better than daylight, because daylight is not a constant quantity. The daylight spectrum in the morning is one thing, at noon another and at night still another; but when scientific societies finally decide on a positive spectrum it can be produced and reproduced by my present system of lighting. Further than this, the color of the light is of extreme importance in the matter of photography. Some of the very finest photographs have been produced by the use of my light alone. You will notice under the tube on this pier photographs of some twenty-five typical installations, which I should be pleased to have you examine. They are interesting from a photographic standpoint, because they were all taken by the light of the tubes themselves.

MR. GEISER: I would ask Mr. Moore how the efficiency of the light is affected by getting a white color.

MR. MOORE: It is about cut in half. That is because nature

has made our eyes as they are. The yellow rays are the maximum luminous rays, and probably as long as the laws of nature last yellow light will be more efficient than white light.

MR. WALLAU: Mr. Moore made the statement that in case the tube were broken it could be fixed in a minute. I understand that when the tube breaks the gases that are in the tube are replaced by atmospheric air, and I ask what process is necessary to bring the tube back to its original efficiency, and how long that will take, aside from the mere splicing of the tube itself.

MR. MOORE: That depends on the size of the tube. In many instances it is not more than half an hour from start to finish. It would be possible to cut a section a foot long out of a tube and in a little over a half hour's time have it again in the same condition as it was before. In many instances when new lamps are presented to this association you go home and wait for two or three years before the lamp is available commercially. But this is a case where central-station men have at the present time an available system of lighting, which will enable an alternating-current central station to compete with a direct-current central station. Up to the present time, owing to the motor factor, direct current has always had an enormous advantage over the alternating current, but now, with this new system, it is possible to produce light 300 or 400 per cent more economically on the alternating current than on the direct current, which now gives the alternating current an enormous advantage. That the system has reached a thoroughly commercial stage of development is proven by the fact that two weeks ago two men in less than a week's time installed two tubes in Pittsburgh. They simply carried with them the necessary kit of tools in a dress-suit case to do the job. These tubes will burn continuously; there are no renewals. A tube will pay for itself in the actual amount of current saved, generally, three times over during the first year.

MR. ALMERT: I want to ask if the tube is in such a state of development that members in the West or Middle West desiring them can secure them; and if after the tube is once installed some accident happens to it, must the tube be kept out of service until a representative of the Moore company can come from New York and repair it?

Mr. Moore: At the present time the commercial development is such that that would be the case; but the probabilities are small of such a happening, and the time is near at hand when every city of any size will have its own installation corps. In fact, a new trade has been introduced; it is not wiring now, it is glass plumbing. Wiremen will have to learn to join glass tubes together. The tube system will do away with 90 per cent of the wiring now used. Further than that, it is simpler in every respect. The tube takes the place of the conduit, wire, fixture, socket, the shade and the lamp, besides many other things that go to make up the complicated, expensive and dangerous incandescent-lamp system.

Mr. Storer: Is the light applicable for different alternations, down as low as 3000 alternations, 25 cycles?

Mr. Moore: I do not know the practical limit in frequency at the present time. There are several thousand feet of tubes running on 60 cycles. The tube on this pier is running on 125 cycles. I gave considerable thought and study to the subject of frequency before the system was finally put on the market, but to my great pleasure I find there have been no objections whatever to a tube on 60-cycle service. The light is absolutely steady.

The President: Does it run on 25 cycles?

Mr. Moore: I believe this room could be lighted on 25 cycles, and the discomfort would not be so great as if it were lighted with arc lamps.

Mr. Alexander Maxwell (New York City): In some of the earlier tubes the power factor was very low; I would ask if that has been improved.

Mr. Moore: The power factor has been very materially improved until now it is about the same as that of the ordinary induction motor or arc lamp—in other words, above 75 per cent. The gentleman referred to some of my earlier installations wherein I was using as a gaseous conductor various chemicals. It was not until about nine months ago that I finally solved this problem of producing light in a lamp by using air instead of carbon, which immediately revolutionized the whole industry. Until six or seven months ago there were very few commercial vacuum tubes in existence; to-day there are thousands of feet of "Moore tubing" in actual commercial use.

THE PRESIDENT: We are touching only one side of the question of new illuminants—the vacuum tube. The discussion will probably be continued after the reading of the next paper, which is *Higher-Efficiency Incandescent Lamps—Their Value and Effect on Central-Station Service,* by Mr. Francis W. Willcox, of Harrison, N. J.

Mr. Willcox read the paper, as follows:

HIGHER-EFFICIENCY INCANDESCENT LAMPS—THEIR VALUE AND EFFECT ON CENTRAL-STATION SERVICE

We are face to face with epoch-making developments in the electric incandescent lamp, by which without reduction in life materially higher efficiencies are obtained, and still higher efficiencies are in prospect.

The discovery by Dr. Whitney at the General Electric Company's research laboratory of the so-called "metallizing" or graphitizing of carbon filaments has already given a veritable 2.5-w.p.c. filament, with promise of still higher efficiencies to come. The discovery and development of the tantalum filament gives a practical lamp of an efficiency of two watts per candle, which is now in regular commercial production in Germany and will soon be manufactured in this country. Experiments carried on in this country and Europe indicate the possibility of manufacturing a 1.5-w.p.c. or even a 1-w.p.c. lamp, so that there is a substantial basis for the belief that within a few years such lamps will be on the market. For the purpose of this paper, however, the question of who invents the lamps, or when they will become marketable, is immaterial. The point is that they are a commercial possibility to be reckoned with in the future.

These remarkable developments possess naturally a special and vital interest to every electric lighting company, and it behooves each central-station manager to study the effects that will follow from the introduction of higher-efficiency lamps and to consider what policy it is wisest and best to adopt for them.

Any one would naturally expect electrical men to rejoice over an advancement in the art by which the electric incandescent lamp may be enabled to hold its own against the Welsbach and other improved competitive illuminants, but there are some central-station managers who regard the higher-efficiency lamp as not an altogether unmixed blessing. Even when regarded favorably, opinions as to the value of higher-efficiency lamps and the effects that will be produced by them differ very greatly among central-station managers.

The time is ripe, therefore, for a full discussion of this very important question. The endeavor will be made in this paper to present a clear analysis of the situation, so that the deducible results can be correctly traced. This analysis, in connection with costs and data on the new improved lamps, will provide a good basis for the study and discussion of the conjectural effects on the electric lighting business. The new General Electric metallized or "GEM"-filament lamp, as it is termed, will be taken as the subject for this discussion.

THE NEW GEM-FILAMENT HIGH-EFFICIENCY LAMP

The GEM filament gives a lamp with a mean initial horizontal efficiency of 2.5 watts per candle and a useful life practically the same as the present 3.1-w.p.c. lamp, so that we have the following comparison of the new with the present lamp:

TABLE I

Present Carbon-Filament Lamp			Useful Life of Both the New and Present Lamp	New GEM-Filament Lamps			
Initial Efficiency in Watts per Candle	Total Watts for 16-CP	Total Watts for 20-CP		Initial Efficiency in Watts per Candle	Total Watts for 16-CP	Total Watts for 20-CP	Per Cent Saving of Power, New Lamp Over Present Lamp
3.1	50	62	450 to 500 Hours	2.5	40	50	20 per cent

The relative life values of the new and present lamp at various efficiencies are clearly shown by Table II and the curves in Figure 1. From these tables and diagram we see that in comparison with the present carbon-filament incandescent lamp

The new GEM-filament lamp saves 20 per cent in energy consumed for same life and candle-power service.

The new GEM-filament lamp gives 25 per cent more candle-power for the same energy consumed and equal life and candle-power maintenance.

The probable cost of the new lamps will be more than the cost of the present lamps, and for the purpose of this paper we will take the cost of the 16 to 20-cp GEM-filament lamp as 20 cents as compared to 16 cents for the present lamp in order to have a definite basis for calculation.

From this information on the lamp we can determine the saving the new lamp will secure to users and therefore its value or worth.

VALUE OF THE HIGH-EFFICIENCY LAMP TO THE CONSUMER

The saving to the consumer paying for current on a regular meter basis is readily calculated.

The consumer's saving using 16-cp new lamps in place of the 16-cp present type is given for different rates and different efficiencies, by Tables III and IV and Figure 3, covering 1000 hours' service.

TABLE II

(See Figures 1 and 2)

USEFUL LIFE AND LAMP RENEWAL COSTS PER KILOWATT-HOUR of the present 16-cp ordinary carbon-filament lamp and the new 16 and 20-cp, GEM-filament lamp at various initial efficiencies.

Mean Horizontal Efficiency in Watts per Candle	Total Watts for 16-cp Lamp	Values for the Present 16-cp Ordinary Carbon-Filament Lamp at Price of 16c.		Values for the New GEM-Filament 16 and 20 cp. Price 20c.		
					Lamp Renewal Cost per Kw.-Hour in Cents	
		Useful Life in Hours	Lamp Renewal Cost per Kw.-Hour in Cents	Useful Life in Hours	16-cp Lamp	20-cp Lamp
2.0	32.0	....	....	125	5.0	4.0
2.1	33.6	50	9.52	177	3.3	2.7
2.2	35.2	66	6.89	233	2.44	1.95
2.3	36.8	86	5.06	304	1.788	1.43
2.4	38.4	111	3.76	392	1.325	1.06
2.5	40.0	143	2.80	500	1.000	0.80
2.6	41.6	177	2.17	627	0.763	0.614
2.7	43.2	223	1.66	789	0.588	0.469
2.8	44.8	275	1.30	972	0.458	0.367
2.9	46.4	337	1.02	1193	0.360	0.289
3.0	48.0	413	0.81	1458	0.286	0.228
3.1	49.6	500	0.64	1766	0.229	0.183
3.2	51.2	595	0.52	....	....	....
3.3	52.8	715	0.42	....	....	....
3.4	54.4	850	0.34	....	....	....
3.5	56.0	1050	0.27	....	....	....
3.6	57.6	1200	0.23	....	....	....
3.7	59.2	1400	0.19	....	....	....
3.8	60.8	1620	0.16	....	....	....
4.0	64.0	2100	....	....	....	....

Assuming that central station is supplying free renewals of the present 3.1-w.p.c. lamps, we see from Table III and Diagram 3 that the consumer could buy his own renewals of the new 2.5-w.p.c. lamps at 25 cents each and save money at all rates above 5 cents per kilowatt-hour.

VALUE TO ISOLATED PLANTS

In the case of the isolated plants of the country the substitution of the new 16-cp lamp of the same useful life as the present

16-cp, 3.5-w.p.c. lamp, would result in an annual saving of over $1,000,000, covering power and apparatus costs. The additional annual cost for lamp renewals of the new lamp would not, however, exceed one-fourth of this saving.

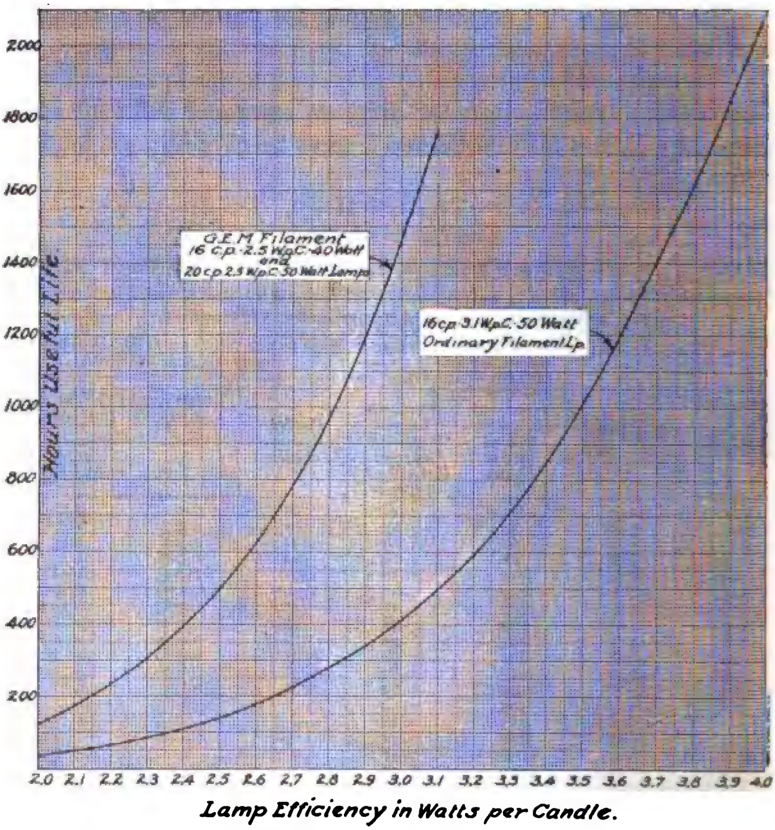


FIG. 1—USEFUL LIFE CURVES OF NEW GEM-FILAMENT LAMP AND PRESENT CARBON-FILAMENT LAMP (SEE TABLE II)

VALUE TO CENTRAL-STATION COMPANIES

The value of a higher-efficiency lamp to central-station operating companies is a complicated question.

With companies selling current by meter at various rates per kilowatt-hour and limited to the same number and candle-power of lamps supplied, and the same hours of use, there would theo-

retically appear to be somewhat of a reduction in income, and a somewhat increased cost of lamp renewals, but as I will show later I do not expect to see the income reduced, but on the contrary largely increased.

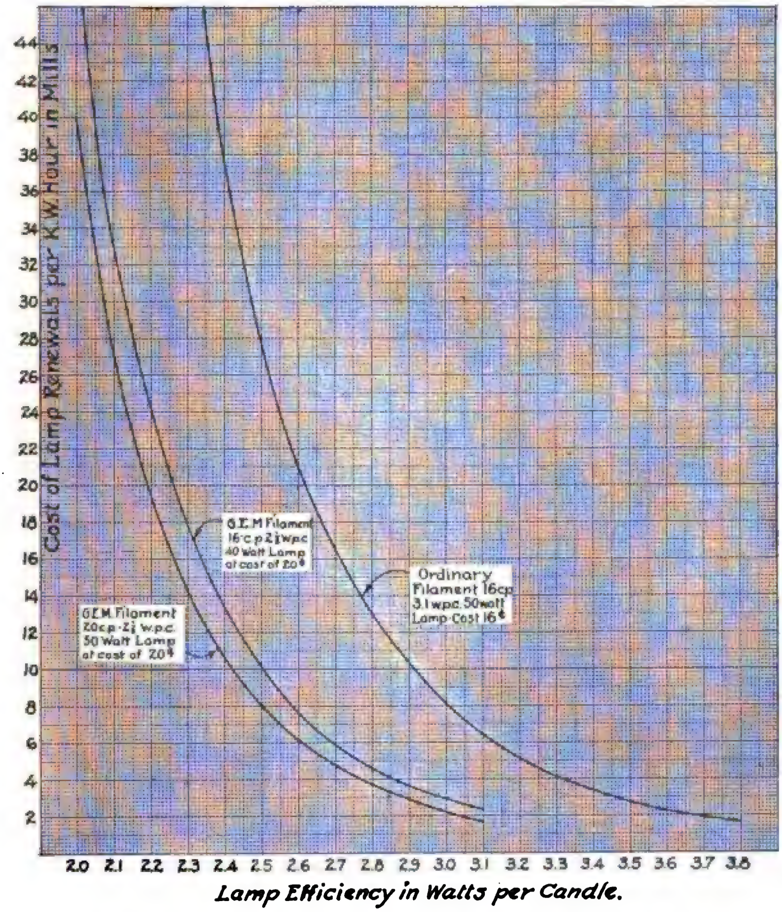


FIG. 2—LAMP-RENEWAL COST CURVES OF NEW GEM-FILAMENT LAMPS (SEE TABLE II)

Where companies are selling by the lamp-hour, or flat charges per lamp per month, the new higher-efficiency lamps have a distinctly positive value.

This value lies in the saving a higher-efficiency lamp will

TABLE III

(See Diagram Figure 3)

SAVING OF HIGHER-EFFICIENCY LAMPS OVER 3.1-W.P.C. LAMPS IN CENTS PER 1000 HOURS OF SERVICE OF A 16-CP LAMP

Rate per Kw-Hr. in Cents	2 W.P.C.	2.1 W.P.C.	2.2 W.P.C.	2.3 W.P.C.	2.4 W.P.C.	2.5 W.P.C.	2.6 W.P.C.	2.7 W.P.C.	2.8 W.P.C.	2.9 W.P.C.	3.0 W.P.C.	3.1 W.P.C.
1	18	16	14.4	12.4	11	10.0	8.0	6.0	4.5	3.0	1.5	00
2	35	32	28.8	24.8	22	19.0	16.0	12.0	9.5	6.0	3.0	00
3	53	48	43.2	37.2	34	29.0	24.0	19.0	14.2	9.4	4.5	00
4	70	64	57.6	49.6	45	38.8	32.0	25.0	19.1	13.6	6.2	00
5	88	80	70.0	62.0	56	48.0	40.0	32.0	24.0	16.0	8.0	00
6	105	96	86.4	74.4	67	57.5	48.0	38.5	29.0	19.0	9.5	00
7	123	112	100.8	86.8	79	68.5	56.0	45.0	33.6	22.3	11.0	00
8	140	128	115.2	99.2	90	78.0	64.0	51.0	38.5	25.6	12.8	00
9	158	144	129.6	101.6	101	86.5	72.0	58.0	43.0	29.0	14.4	00
10	176	160	144.0	124.0	112	96.0	80.0	64.0	48.0	32.0	16.0	00
11	194	176	158.4	136.4	123	105.5	88.0	70.0	52.8	35.0	17.8	00
12	211	192	172.8	148.8	134	115.0	96.0	77.0	57.8	38.5	19.2	00
13	229	208	187.2	161.2	146	125.0	104.0	83.0	62.5	41.5	20.8	00
14	247	224	201.6	173.6	157	135.0	112.0	89.0	67.1	44.8	22.5	00
15	264	240	216.0	186.0	168	144.0	120.0	96.0	72.0	48.0	24.0	00

TABLE IV

SAVING OF HIGHER-EFFICIENCY LAMPS OVER 3.5-W.P.C. LAMPS IN CENTS PER 1000 HOURS OF SERVICE OF A 16-CP LAMP

Rate per Kw-Hr. in Cents	2.5 W.P.C.	2.6 W.P.C.	2.7 W.P.C.	2.8 W.P.C.	2.9 W.P.C.	3.0 W.P.C.	3.1 W.P.C.	3.5 W.P.C.
1 cent	16.5	14.5	13.0	11.0	9.5	8.0	6.5	00
2 cents	32.5	29.0	26.0	22.0	19.0	16.0	12.8	00
3 cents	48.5	43.5	38.6	33.5	29.0	24.0	19.1	00
4 cents	64.5	58.0	51.0	44.5	38.5	32.0	25.6	00
5 cents	80.5	72.5	64.0	56.0	48.0	40.0	32.0	00
6 cents	96.5	87.0	77.0	67.0	57.5	48.0	38.5	00
7 cents	112.0	101.0	90.0	78.1	67.0	56.0	44.8	00
8 cents	128.0	115.5	102.5	89.6	77.0	64.0	51.1	00
9 cents	144.0	130.0	115.0	100.5	86.5	72.0	57.6	00
10 cents	160.0	144.0	128.0	111.5	96.0	80.0	64.0	00
11 cents	176.0	159.0	141.0	123.0	105.5	88.0	70.5	00
12 cents	192.0	173.0	154.0	134.0	115.0	96.0	77.0	00
13 cents	208.0	187.5	166.0	145.0	125.0	104.0	83.0	00
14 cents	224.0	202.0	179.0	157.0	134.5	112.0	89.8	00
15 cents	240.0	216.b	192.0	168.0	144.0	120.0	96.0	00

secure (for a given lighting output) in the station capacity and in generating costs that are strictly proportionate to output.

This saving is made up of two items:

(a) The saving in generating costs that are strictly proportionate to output.

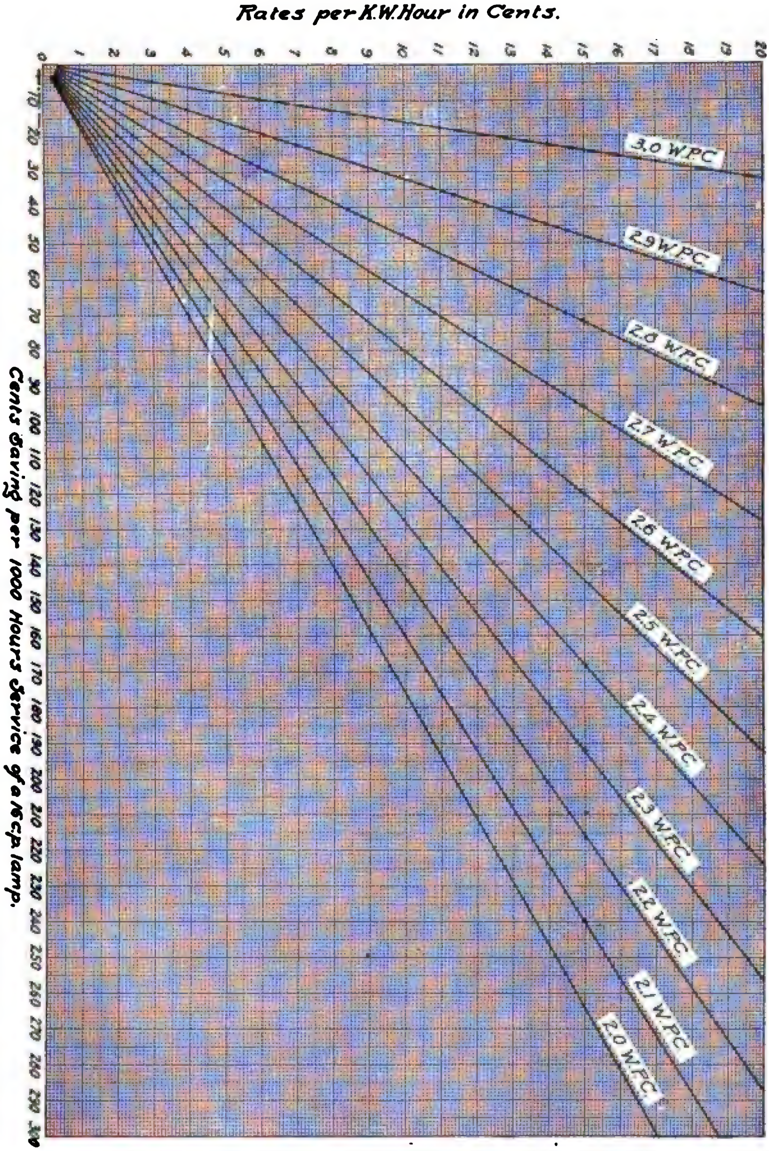


FIG. 3—DIAGRAM GIVING SAVING PER 1000 HOURS' SERVICE OF A 16-CP LAMP BY HIGHER-EFFICIENCY LAMPS IN COMPARISON WITH PRESENT 3.1-W.P.C. LAMP (SEE TABLE III)

(b) The saving in fixed charges on the investment in generating apparatus.

As regards the generating costs that are strictly proportional to the output, the principal item is boiler fuel. Engine and boiler-room labor and repairs are affected slightly. Assuming that boiler-room labor alone is affected, it would be about the equivalent of the slight changes in various other expenses. So that we can take fuel and boiler-room labor costs to represent the total of those generating costs that are strictly proportional to output, and calculate therefrom the value of the current consumed by the new high-efficiency as compared to the present lamp. These costs should be taken at their value at the lamp, *i. e.*, the costs obtained by dividing the fuel and boiler-room labor costs for incandescent lighting by the output delivered and metered at the lamp.

For this purpose, let us assume several values for fuel and boiler-room labor costs per kilowatt-hour of current delivered at lamp, *viz.*, 1 cent, 0.5 cent and 0 cent per kilowatt-hour, covering the cases of steam-operated plants down to water-power plants, for which these charges are taken as nothing.

With respect to the saving in fixed charges, the items are taxes, interest and depreciation on boilers, engines and dynamos. Should a station introduce higher-efficiency lamps, say a 40-watt lamp for a 50-watt lamp, it would have available for same number of lamps supplied 20 per cent more capacity of generating equipment. This added capacity of apparatus, considered as an asset, might be converted into cash to reduce investment account; or, more logically, it would serve to provide needed capacity for increased business. As time goes on and the demand for light increases, this excess station capacity is realized on without adding to investment, and therefore central stations can consider this a saving.

We can take taxes, interest and depreciation charges at a total of 12 per cent. The investment per kilowatt for the increment or decrement of generating apparatus will vary for different stations, but we can assume $125 as a safe value. On this basis we obtain with our total fixed-charge percentage of 12 per cent $15 per year as the fixed charge per kilowatt of station capacity.

This annual fixed-charge cost of $15 per kilowatt can be

reduced to the value per lamp per year as shown in the following table:

Lamps Considered	Useful Life in Hours	Lamps per KW	Candles per KW	Fixed-Charge Cost per Year in Cents Per Lamp
GEM-filament lamp, 16-cp, 40 watts	500	25.	400.	60.
Ordinary-filament lamp, 16-cp, 50 watts	500	20.	320.	75.
GEM-filament lamp, 20-cp, 50 watts	500	20.	400.	75.
GEM-filament lamp, 16-cp, 45 watts	1000	22.2	355.5	67.5
Ordinary-filament lamp, 16-cp, 56 watts	1000	17.84	285.4	84.
Tantalum-filament lamp, 25-cp, 50 watts	800	20.	500.	75.

THE COST OF PRODUCING A CANDLE-HOUR OF LIGHT WITH LAMPS OF DIFFERENT EFFICIENCIES

To determine the cost on the candle-*hour* or kilowatt-*hour* basis it is necessary to determine how long the lamps are used. For this purpose we can assume several values for the annual hours' use of lamp per year and determine the candle-hour cost therefrom by dividing the fixed charge per 1000 candles (in above table) by the assumed hours' use per year. We can now make up a table as shown on page 606 (Table V), giving for the lamps of various efficiencies the lamp-renewal costs, fixed-charge costs, fuel and station-labor costs, and their sum or total cost for the assumed hours' use of lamp per year. This basis is the theoretically correct one, as it covers the change in candle-power of lamp. For those companies who wish to determine the cost on a kilowatt-hour basis for an equal number of lights the proposition has been computed on this basis and the tables (Table VI) and curves (Figure 6), similar to Table V and Figure 5, are given in the appendix to this paper where they may be consulted and studied. They were placed in the appendix to avoid confusing the discussion by insertion at this point.

TABLE V

(Results Diagrammed in Figure 5)

TABLE SHOWING RELATIVE COSTS OF PRODUCING A CANDLE-HOUR OF LIGHT WITH INCANDESCENT LAMPS OF DIFFERENT EFFICIENCIES COVERING LAMP-RENEWAL COSTS AND THOSE STATION COSTS WHICH WOULD BE EFFECTED BY CHANGE IN LAMP EFFICIENCY FOR THE SAME AMOUNT OF LIGHT SUPPLIED

Lamps Compared	(1) First Cost of Lamp in Cents	(2) Efficiency of Lamp in W.P.C.	(3) Useful Life in Hours	(4) Fixed Charge Cost in Cents per Lamp per Year	(5) Cost in Cents of Lamp Renewals per 1000 Candle-Hours	(6) Fixed Cost in Cents per 1000 Candle-Hours on the Basis of								
						100 Hrs. Use of Lamp per Year	200 Hrs. Use of Lamp per Year	300 Hrs. Use of Lamp per Year	400 Hrs. Use of Lamp per Year	500 Hrs. Use of Lamp per Year	800 Hrs. Use of Lamp per Year	1000 Hrs. Use of Lamp per Year	1500 Hrs. Use of Lamp per Year	2000 Hrs. Use of Lamp per Year
GEM-filament, 40-watt lamp 16-cp, 2.5-w.p.c.	20	2.5	500	60.0	2.50	37.5	18.75	12.5	9.37	7.50	4.68	3.75	2.50	1.875
Ordinary-carbon filament, 50-watt lamp 16-cp, 3.1-w.p.c.	16	3.1	500	75.0	2.00	46.8	23.40	15.6	11.70	9.36	5.80	4.68	3.12	2.340
GEM-filament, 50-watt lamp 20-cp, 2.5-w.p.c.	20	2.5	500	75.0	2.00	37.5	18.75	12.5	93.70	7.50	4.68	3.75	2.50	1.875
GEM-filament, 45-watt lamp 16-cp, 2.8-w.p.c.	20	2.8	1000	67.5	1.25	42.2	21.10	14.0	10.50	8.40	5.27	4.22	2.80	2.110
Ordinary-carbon filament, 56-watt lamp 16-cp, 3.5-w.p.c.	16	3.5	1000	84.0	1.00	52.5	26.25	17.50	13.10	10.50	6.56	5.25	3.50	2.625
Tantalum-filament, 50-watt lamp 25-cp, 2.0-w.p.c.	60	2.0	*800	75.0	3.00	30.0	15.00	10.0	7.50	6.00	3.75	3.00	2.00	1.500

* Approximate value on direct current.

TABLE V—*Continued*

Lamps Compared	(7) Fuel and Station Labor Expense in Cents per 1000 Candle-Hours at Different Assumed Costs per Kw-Hour	(8) Total Cost in Cents per 1000 Candle-Hours of Light (Sum of Columns 5, 6 and 7), on the Basis of 100 Hours Use of Lamp per Year	200 Hours Use of Lamp per Year	300 Hours Use of Lamp per Year	400 Hours Use of Lamp per Year	500 Hours Use of Lamp per Year	800 Hours Use of Lamp per Year	1000 Hours Use of Lamp per Year	1500 Hours Use of Lamp per Year	2000 Hrs. Use of Lamp per Year
GEM-filament, 40-watt lamp	@ 1 c. per kilowatt-hour = 2.5 c.	42.50	23.75	17.50	14.37	12.50	9.68	8.75	7.50	6.875
16-cp, 2.5-w.p.c.	@ ½c. " " = 1.25c.	41.25	22.50	16.25	13.12	11.25	8.43	7.50	6.25	5.625
	@ 0 c. " " = 0.00c.	40.00	21.50	15.00	11.87	10.00	7.18	6.25	5.00	4.375
Ordinary-carbon filament, 50-watt lamp	@ 1 c. per kilowatt-hour = 3.11c.	51.91	28.51	20.71	16.81	14.47	10.91	9.79	8.23	7.45
	@ ½c. " " = 1.55c.	50.35	26.95	19.15	15.25	12.91	9.35	8.23	6.67	5.89
16-cp, 3.1-w.p.c.	@ 0 c. " " = 0.00c.	48.80	25.40	17.60	13.70	11.36	7.80	6.68	5.12	4.340
GEM-filament, 50-watt lamp	@ 1 c. per kilowatt-hour = 2.50c.	42.00	23.25	17.00	13.87	12.00	9.18	8.25	7.00	6.375
20-cp, 2.5-w.p.c.	@ ½c. " " = 1.25c.	40.75	22.00	15.75	12.62	10.75	7.93	7.00	5.75	5.125
	@ 0 c. " " = 0.00c.	39.50	20.75	14.50	11.37	9.50	6.68	5.75	4.50	3.875
GEM-filament, 45-watt lamp	@ 1 c. per kilowatt-hour = 2.82c.	46.27	25.17	18.07	14.57	12.47	9.34	8.29	6.87	6.180
16-cp, 2.8-w.p.c.	@ ½c. " " = 1.41c.	44.86	23.76	16.66	13.16	11.06	7.93	6.88	5.46	4.770
	@ 0 c. " " = 0.00c.	43.45	22.35	15.25	11.75	8.24	5.11	4.06	2.64	1.950
Ordinary-carbon filament, 56-watt lamp	@ 1 c. per kilowatt-hour = 3.50c.	57.00	30.75	22.00	17.60	15.00	11.06	9.75	8.00	7.125
	@ ½c. " " = 1.75c.	55.25	29.00	20.25	15.95	13.25	9.31	8.00	6.25	5.375
16-cp, 3.5-w.p.c.	@ 0 c. " " = 0.00c.	53.50	26.25	18.50	14.10	11.50	7.56	6.25	4.50	3.625
Tantalum-filament, 50-watt lamp	@ 1 c. per kilowatt-hour = 2.00c.	35.00	20.00	15.00	12.50	11.00	8.75	8.00	7.00	6.500
25-cp, 2.0-w.p.c.	@ ½c. " " = 1.00c.	34.00	19.00	14.00	11.50	10.00	7.75	7.00	6.00	5.500
	@ 0 c. " " = 0.00c.	33.00	18.00	13.00	10.50	9.00	6.75	6.00	5.00	4.500

If we take the cost of the present 16-cp, 50-watt carbon-filament lamp as a basis at 100 per cent, and plot the values for the other lamps under comparison in percentages of the present 16-cp, 50-watt lamp for different hours' use per lamp per year, we have the curves as shown in Figure 5.

Figure 5 gives the percentage relation for equal candle-hour

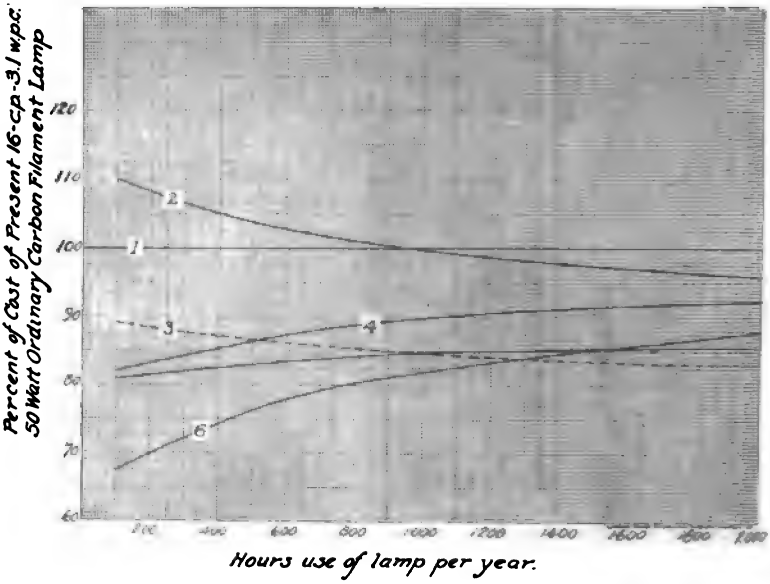


FIG. 5—CURVES SHOWING RELATIVE COST OF PRODUCING A CANDLE-HOUR OF LIGHT WITH LAMPS OF DIFFERENT EFFICIENCIES. EXPRESSED IN PER CENT OF COSTS GIVEN WITH PRESENT 16-CP, 3.1-W.P.C., 50-WATT LAMPS (SEE TABLE V)

Fuel and station labor costs,	1 cent per kilowatt-hour
Lamp costs—New GEM filament,	20 cents
Tantalum "	60 cents
Present "	16 cents

1.	Present carbon-filament,	16-cp,		3.1-w.p.c.,		50-watt lamp				
2.	" "	"	16	"	3.5	"	56	"		
3.	New GEM	"	16	"	2.8	"	45	"		
4.	" "	"	16	"	2.5	"	40	"		
5.	" "	"	20	"	2.5	"	50	"		
6.	Tantalum	"	25	"	2.0	"	50	"		

values, and presents an interesting diagrammatic picture of the value of higher-efficiency lamps as compared to the present 3.1-w.p.c. lamp.

In studying this diagram it should be noted that the average hours' use per lamp by consumers does not in general exceed 1000 hours per year or three hours per day.

From the curves in Figure 5 we see:

First—That the cost of producing a candle-hour of light is materially diminished by the use of the GEM-filament lamp in either 16 candle-power (curves Nos. 3 and 4) or 20 candle-power (curve No. 5) in place of the regular carbon-filament, 16-cp, 3.1-watts-per-candle (curve No. 1).

Second—That with the tantalum lamp (curve No. 6) the cost of producing a candle-hour of light is also much lower than with the regular carbon-filament, 16-cp, 3.1-watts-per-candle lamp (curve No. 1) within the limit of 2000 hours' service shown.

EFFECT UPON THE QUESTION OF SELLING LIGHT BY THE KILOWATT-HOUR

This is an interesting comparison of values of lamps of different efficiencies, but it must not be overlooked that the basis of comparison assumed is equal light or number of lamps. The comparison is a true one for a factory or building, or a street railway requiring a certain lighting result without reference to any sale to consumer.

Where central stations are selling by the lamp or candle-hour, this comparison also holds for actual results. Unfortunately, however, the majority of central-station selling is done by the kilowatt-hour, so that our actual comparisons of the new and present lamps must be made on the basis of kilowatt-hours absolute instead of by kilowatt-hours per lamp or by candle-hours.

On the absolute kilowatt-hour basis with load factor unchanged, the change to higher-efficiency lamps would theoretically appear to increase the central-station kilowatt-hour costs by the slight amount of increase in cost of lamp renewals for the new lamp.

For the same light and hours of use the total kilowatt-hour output with higher-efficiency lamps would be reduced and the total cost probably in a similar proportion so that the cost per kilowatt-hour would not theoretically be reduced but might remain either unchanged or slightly increased.

So far as the central station is concerned with a given output in kilowatt-hours to sell, and paid for it only by the kilowatt-hour, it would appear to make practically no difference in the economy of the station whether it be sold in high or low-efficiency

lamp units (or in high or low candle-power units), except in cost of lamp renewals.

From the station-cost standpoint, therefore, the logic of the situation would seem to point to the use of the lamp of the lowest renewal cost, *i. e.*, the extreme of low-efficiency lamps.

Why then should not this course be followed, and instead of developing a higher-efficiency 2.5-w.p.c. lamp to replace our present 3.1-w.p.c. lamp, why should not central-station companies adopt a 4-w.p.c. lamp, or a 5-w.p.c. lamp? Simply because the central-station-cost standpoint is not the correct basis on which to determine the proper efficiency of lamps where light is sold by the kilowatt-hour. It neglects to consider the effect upon the customer and the selling end of the business. Whether a central station supplies free lamp renewals or not, and whether its costs are thereby changed or unaffected, the success of the business demands the lowest practicable cost to consumer—that is, it requires the use of high-efficiency lamps—of that efficiency which gives the lowest cost of light (including power and lamp renewals) at the rate paid.

THE CONSIDERATION DETERMINING THE VALUE

The value, then, of the new 2.5-watt lamp (or any higher-efficiency lamp) lies in the general stimulus it will give to the growth of electric light service resultant from the 20 per cent improvement in efficiency for the same candle-power (or a 25 per cent increase in light for the same wattage), equivalent to a 20 per cent reduction in rates.

This value is, in a measure, of course, conjectural, as it can not be fully and definitely determined, but it should be none the less an actual and positive value.

The proposition simply stated is:

The new lamp will enable central stations (now on a free-renewal basis), by increasing their total expense only about one per cent, to give an equal volume of light at 20 per cent lower cost to their consumers, or 25 per cent more light for an equal expenditure.

The value of this improvement in service in meeting and resisting competition, in adding desirable business, in improving the load factor and in increasing net earnings—this is the important point of the whole question, which should be fully discussed from the viewpoint and experience of central-station managers.

WHAT DETERMINES THE DESIRABLE LAMP EFFICIENCY

It will assist here perhaps to consider the general question of what constitutes the best efficiency for central-station service. In my paper on the subject of efficiencies before the 1902 convention I stated the following:

"The best efficiency for central-station service is the one securing the greatest amount of net earnings. Net earnings are the product of per cent of profit by amount of business. There is a point of balance between these two factors at which their product, the net earnings, becomes a maximum.

"The largest profits are not secured by exacting the highest per cent profit, but, on the contrary, are generally secured by low prices and small per cent of profit, thereby increasing the gross business and swelling the total profit. In other words, we are concerned not so much as to the cost of our commodity (costs may be, and frequently are, increased with advantage); not so much with per cent of profit, but chiefly with so fixing the selling price, and pushing the business as to increase the sales to the point of securing the maximum profit.

"Applying this idea to the question of lamp efficiency, we would say that the most desirable efficiency is not the efficiency which will return the highest per cent of profit from customers; but rather is it that efficiency which for any given rate will secure to the electric lighting company the greatest amount of profit, swelling the gross profitable business, not only by augmenting the number of lamps connected, but also by increasing the average hours of use so as to bring in the fullest net returns."

It is particularly in the improvement in load factor through increased hours of use resulting from reduced costs of lighting that central-station companies can look to for the improvement of their net earnings.

EXHIBIT A

Elements of Lighting Service

Table A—1 Arranged in several assumed combinations for the purpose of comparing the effect of changing from the present 3.1-w.p.c. lamp to the new GEM-filament, 2.5-w.p.c. lamp.

Example	Number of Lamps (L)	Candle-Power of Lamp	Watts (W) per Lamp	Hours' Use (H)	Kw-Hours Consumed	Concrete Expression for Kw-Hours
1	The same	The same	Reduced 20%	The same	Reduced 20%	(L) × (W[illegible]) × (H)
2	25% more	" "	" "	" "	The same	([illegible]L) × (W[illegible]) × (H)
3	The same	" "	" "	25% more	" "	(L) × (W[illegible]) × ([illegible]H)
4	25% more	" "	" "	" "	Increase 25%	([illegible]L) × (W[illegible]) × ([illegible]H)
5	The same	25% more	The same	The same	The same	(L) × (W) × (H)

COMPARISON OF EFFECT ON STATION OPERATION

Table A—2 of changing from the present 3.1-w.p.c. lamp to the new GEM-filament, 2.5-w.p.c. lamp.

Example	Assumed Conditions	Kw Capacity of Apparatus Required Affecting Fixed Charge Expense on Investment in Apparatus			Fuel Cost			Lamp-Renewal Costs (Assuming that the New GEM 2.5-w.p.c. Lamp Costs 25% More than Present 3.1-w.p.c. Lamp)		
		Total	Per Lamp Demanded	Per Kw-Hr. Generated or Sold	Total	Per Lamp Demanded	Per Kw-Hr. Sold	Total	Per Lamp Demanded	Per Kw-Hr. Sold
1	Total watts per lamp reduced 20%; number of lamps, cp and hours' use unchanged.	Saving 20%	Saving 20%	No change	Saving between 20% and 10%	Saving between 20% and 10%	Small increase	Increase 25%	Increase 25%	Increase 56%
2	Total watts per lamp reduced 20%; number of lamps increased 25%; cp and hours' use unchanged.	No change	Saving 20%	No change	No change	Saving 20% and 10%	No change	Increase 56%	Increase 25%	Increase 56%
3	Total watts per lamp reduced 20%; number of lamps and cp unchanged; hours' use increased 25%.	Saving 20%	Saving 20%	Saving 20%	Slight saving	Slight saving	Slight saving	Increase 56%	Increase 56%	Increase 56%
4	Total watts per lamp reduced 20%; number of lps. increased 25%; cp unchanged; hours' use increased 25%.	No change	Saving 20%	Saving 20%	Increase	Saving 4%	Small saving	Increase 95%	Increase 56%	Increase 56%
5	Total watts per lamp and number of lamps unchanged; cp increased 25%; hours' use unchanged	No change	No change	No change	No change	No change	No change	Increase 25%	Increase 25%	Increase 25%

TABLE A—3

COMPARISON OF TOTAL EFFECT ON CENTRAL-STATION INCOME

of changing from the present 3.1-w.p.c. lamp to the new GEM-filament, 2 5-w.p.c. lamp, under different systems of rates, assuming that rates remain the same per unit.

Example	Assumed Conditions	Lamp-Hour Rate	Flat Rate per Lamp per Month	Straight Meter Rates per Kw-Hr.	Combination Flat and Meter		Wright Demand System		Differential System Based on so Many Hrs. Use of Capacity of Installation		Doherty's System		
					Flat Portion	Meter Portion	High Rate Portion	Low Rate Portion	High Rate	Low Rate	Charge per Consumer per Year	Charge per Lamp per Year	Low Rate Portion on Meter per Kw-Hour
1	Total watts per lamp reduced 20%; number of lamps, cp and hours' use unchanged.	No change	No change	Decrease 20%	No change	Decrease 20%	Decrease 20%	Decrease 20%	Decrease 20%	Decrease 20%	No change	No change	Decrease 20%
2	Total watts per lamp reduced 20%; number of lps. increased 25%; cp and hours' use unchanged.	Increase 25%	Increase 25%	No change	Increase 25%	No change	No change	No change	No change	No change	Increase	Increase 25%	No change
3	Total watts per lamp reduced 20%; number of lamps and cp unchanged; hours' use increased 25%.	Increase 25%	No change	No change	No change	No change	Decrease 20%	Increase 15%	Decrease 20%	Increase about 30%	No change	No change	Increase 25%
4	Total watts per lamp reduced 20%; number of lps. increased 25%; cp unchanged; hours' use increased 25%.	Increase 25%	Increase 25%	Increase 25%	Increase 25%	Increase 25%	No change	Increase about 44%	No change	* Increase about 60%	Increase	Increase 25%	Increase 25%
5	Total watts per lamp and number of lamps unchanged; cp increased 25%; hours' use unchanged.	Increase if an extra charge be made per lamp hr. for higher cp. lamp. If no extra charge, then no change.	Increase if an extra charge be made per lamp for higher cp. If no increase, then no change.	No change	Increase if an extra charge be made per lamp for higher cp. If no increase, then no change.	No change	No change	No change	No change	No change	No change	Increase if an extra charge is made for higher cp. If no increase, then no change.	No change

* Depends upon number of hours' use per day taken as basis.

EXHIBIT B

Comparison of Actual Effect on Total Operating Expense

of changing from present 3.1-w.p.c. lamp to the new GEM-filament, 2.5-w.p.c. lamp. Taken for the case of central station described in Tables VII and VIIA, page 615. Total central-station expense, $38.480.

Example	Assumed Conditions	Change in Fixed Charges on Investment in Apparatus Required for Max. Demand	Change in Fuel Costs	Change in Lamp-Renewal Costs	Net Total
1	Total watts per lamp reduced 20%; number of lamps, cp and hours of use unchanged	* Theoretical saving $900, about 2.5% of total expense (see note below)	† Saving $372, about 1% of total expense	Increase $375, about 1% of total expense	Theoretically $900, saving, about 2.5% of total expense
2	Total watts per lamp reduced 20%; number of lamps increased 25%; cp and hours of use unchanged	No change	No change	Increase $840, about 2.3% of total expense	Increase $840, about 2.3% of total expense
3	Total watts per lamp reduced 20%; number of lamps and cp unchanged; hours of use increased 25%	* Theoretical saving about $900, or about 2.5% of total expense (see note below)	No change	Increase $840, about 2.3% of total expense	$900 (theoretical) less $840 (actual), or $60 saving theoretically
4	Total watts per lamp reduced 20%; number of lamps increased 25%; cp unchanged; hours of use increased 25%	No change	‡ Increase $372, about 1% of total expense	Increase $1425, about 4% of total expense	Increase $1800, about 4.7% of total expense
5	Total watts per lamp and number of lamps unchanged; cp increased 25%; hours of use unchanged	No change	No change	Increase $375, about 1% of total expense	Increase $375, about 1% of total expense

* Assumption is 20% saving capacity equals 15% saving in cost on $50,000 of apparatus—the portion affected, and that annual charge is 12% of this, or $900

† Assumed total coal saving 15%.

‡ Assumed total coal consumed increase 15%.

Note—Should a station substitute a 40-watt lamp for a 50-watt lamp, it would have available for the same number of lamps, excess 20% station capacity of apparatus, which considered as an asset might be converted into cash to reduce investment account, and so forth, or would serve providing capacity for power sales, and so forth. As time goes on and the demand for lights increases, this excess station capacity is realized on without adding to investment and therefore central stations consider this as a saving as indicated above.

TABLE VII

Details of the capital investment of a central station referred to by Mr. Henry L. Doherty before the National Electric Light Association meeting in 1900, used as an example for deductions in Exhibit B, page 614.

ESTIMATED VALUE OF STATION, SHOWING HOW FIXED CHARGES ARE OBTAINED

Real Estate	$5,000.00	@ 5 per cent app.	$250.00
Building	6,000.00	@ 5 per cent dep.	300.00
Boilers, heaters and pumps	12,000.00	@ 5 per cent	960.00
Engines and condensers	15,000.00	@ 8 per cent	1,200.00
Generators	12,000.00	@ 8 per cent	960.00
Switchboard	3,000.00	@ 10 per cent	300.00
800 poles set cross-armed	12,000.00	@ 15 per cent	1,800.00
60,000 pounds wire at 18 cents	10,800.00	@ 2½ per cent	260.00
Stringing wires	3,000.00		
Transformers	7,500.00	@ 8 per cent	600.00
1000 service connections at $5.00	5,000.00	@ 10 per cent	500.00
Lightning arresters and incidentals	3,000.00	@ 10 per cent	300.00
Engineering and supervising	6,000.00		
Legal expenses and rights	3,000.00		
Interest while building	6,000.00		
925 meters at $15.00	13,875.00	@ 10 per cent	1,387.50
18,000 lamps at 17 cents	3,060.00		
	$126,230.00	6.62 per cent	$8,917.50
Taxes at 2 per cent of 50 per cent			1,252.30
Interest			6,311.50
			$15,891.30

Income and sales—$38,480.18; 307,389 kilowatt-hours sold, average price, $0.12518.
Connected up—900 consumers; 925 meters, 18,000 lamps.
Consumption—341.4 kilowatt per consumer, 332.1 per meter, 17.06 per lamp.

TABLE VIIA

Details of operating expenses of a central station referred to bv Mr. Henry L. Doherty in the National Electric Light Association Proceedings for 1900, used as an example for deductions in Exhibit B, page 614.

TABLE OF DETAILED OPERATING EXPENSES DIVIDED INTO READINESS TO SERVE CHARGE AND RUNNING CHARGES

		Total Expense	Expenses Proportionate to kilowatt output	Minimum expense for readiness to serve
1.	Fuel	$2,478.00	$2,478.00	......
2.	Oil and waste	176.00	88.00	$88 00
3.	Repairs—boilers and engines	493.00	393.00	100.00
4.	Repairs—dynamos and switchboards	88.00	88.00	......
5.	Repairs—buildings and property	132.00	32.00	100.00
6.	Station labor	4,518.00	1,338.00	3,180.00
7.	Repairs—coal lines and conductors	1,500.00	500.00	1,000.00
8.	Transformer maintenance	400.00	200.00	200.00
9.	Meter maintenance	640.00	400.00	240.00
10.	Reading meters	336.00	......	336.00
11.	Lamp repairs and renewals	1,500.00	1,500.00	......
12.	Complaints, etc.	600.00	600.00	......
13.	Office salaries and collecting	2,150.00	650.00	1,500.00
14.	Office rent	600.00	......	600.00
15.	Sundry expenses	1,200.00	600.00	600.00
16.	Fire insurance	500.00	......	500.00
17.	Liability insurance	500.00	250.00	250.00
18.	Public liability insurance	250.00	......	250.00
19.	Superintendence	1,500.00	500.00	1,000.00
20.	Executive salaries	2,000.00	......	2,000.00
21.	Taxes	1,262.27	......	1,262.27
22.	Interest	6,313.99	......	6,313.99
23.	Depreciation	8,317.50	......	8,317.50
24.	Profit	1,025.42	1,025.42	......
	Total	$38,480.18	$10,642.42	$27,837.76

Expense per consumer	$9.898
Expense per meter	3.022
Expense per lamp wired up	0.8963
Expense per lamp demanded on station	2.0166
Expense per lamp demanded by consumers	1.3444
Expense per kilowatt-hour sold	0.03575

It is desired, therefore, that this discussion bring out what is the improvement of load factor resulting from reductions in rates or their equivalent. The general effect of reduction in rates should cause a broadening of load peaks and consequent material improvement in load factor. This would seem to be so, because if the cost of electric lighting is reduced to an equality with gas and other illuminants, it should insure a more extended use of electric light fully equal to that obtained with any other illuminant.

THE EFFECT ANALYZED

To guide the discussion on this question, the accompanying exhibit (Exhibit A), page 612, has been prepared, which presents in table form a clear analysis of the effect produced by the introduction of higher-efficiency lamps for an assumed set of conditions relating to candle-power of lamp, number of lamps demanded and hours' use per lamp, upon,—

First—Station operation.

Second—Lamp-renewal costs.

Third—Central-station income.

Exhibit A gives the results for the general case and Exhibit B the actual effects in the specific case of a given central station.

The table No. A-3 in this exhibit shows clearly the advantages of the lamp-hour rate of those rate systems like that of Mr. Henry L. Doherty, having a combination flat meter rate with a charge per lamp. All such rate systems derive positive, deducible advantage from the introduction of the higher-efficiency lamp.

ADVANTAGES OF A LAMP-HOUR AND CANDLE-HOUR RATE

This clearly shows the advantage of supplementing the pure kilowatt-hour meter rate with a charge per lamp in some form or other. The merits and demerits of this as a general proposition I will leave to be decided by experts on rate questions, but it is patent that a central station can not reap the full benefits of any improvement in lamp efficiency unless charges in some way are made to include the lamp or candle-hour value. The new high-efficiency lamp enables us to produce a given amount of light cheaper, as already indicated, but theoretically increases the cost for a given amount of kilowatt-hours. As a result, the benefit apparently all goes to the consumer with little or no return to the lighting company, if we exclude the stimulating effect upon business.

TABLE IX

COST OF 1000 CANDLE-HOURS OF LIGHT IN CENTS

WITH DIFFERENT LAMP EFFICIENCIES AT VARIOUS RATES PER KILOWATT-HOUR

Rates per Kw-Hr. in Cents	3.5 W.P.C.	3.3 W.P.C.	3.1 W.P.C.	3.0 W.P.C.	2.8 W.P.C.	2.7 W.P.C.	2.6 W.P.C.	2.5 W.P.C.	2.4 W.P.C.	2.3 W.P.C.	2.0 W.P.C.
1	3.5	3.3	3.1	3.0	2.8	2.7	2.6	2.5	2.4	2.3	2.0
2	7.0	6.6	6.2	6.0	5.6	5.4	5.2	5.0	4.8	4.6	4.0
3	10.5	9.9	9.3	9.0	8.4	8.1	7.8	7.5	7.2	6.9	6.0
4	14.0	13.2	12.4	12.0	11.2	10.8	10.4	10.0	9.6	9.2	8.0
5	17.5	16.5	15.5	15.0	14.0	13.5	13.0	12.5	12.0	11.5	10.0
6	21.0	19.8	18.6	18.0	16.8	16.4	15.6	15.0	14.4	13.8	12.0
7	24.5	23.1	21.7	21.0	19.6	18.9	18.2	17.5	16.8	16.1	14.0
8	28.0	26.4	24.8	24.0	22.4	21.6	20.8	20.0	19.2	18.4	16.0
9	31.5	29.7	27.9	27.0	25.2	24.3	23.4	22.5	21.6	20.7	18.0
10	35.0	33.0	31.0	30.0	28.0	27.0	26.0	25.0	24.0	23.0	20.0
11	38.5	36.3	34.1	33.0	30.8	29.7	28.6	27.5	26.4	25.3	22.0
12	42.0	39.6	37.2	36.0	33.6	32.4	31.2	30.0	28.8	27.6	24.0
13	45.5	42.9	40.3	39.0	36.4	35.1	33.8	32.5	31.2	29.9	26.0
14	49.0	46.2	43.4	42.0	39.2	37.8	36.4	35.0	33.6	32.2	28.0
15	52.5	49.5	46.5	45.0	42.0	40.5	39.0	37.5	36.0	34.5	30.0
16	56.0	52.8	49.6	48.0	44.8	43.2	41.6	40.0	38.4	36.8	32.0
17	59.5	56.1	52.7	51.0	47.6	45.9	44.2	42.5	40.8	39.1	34.0
18	63.0	59.4	55.8	54.0	50.4	48.6	46.8	45.0	43.2	41.4	36.0
19	66.5	62.7	58.9	57.0	53.2	51.3	49.4	47.5	45.6	43.7	38.0
20	70.0	66.0	62.0	60.0	56.0	54.0	52.0	50.0	48.0	46.0	40.0

The values in Tables IX and X well illustrate this point. Table IX shows the cost per 1000 candle-hours of light to consumers for different lamp efficiencies and rates per kilowatt-hour. Table X shows various values for higher-efficiency lamps as compared to present lamps. These tables bring out the benefit of higher-efficiency lamps to the consumer buying on the kilowatt-hour basis, in the reduction in cost per 1000 candle-hours of light. As shown by column No. 5, Table X, this cost is only 20 cents for the tantalum lamp as compared with 31 cents for the present 16-cp, 50-watt lamp at 10 cents per kilowatt-hour rate. Also by the last column of Table X we see that the income from the tantalum lamp on the candle-hour basis is 50 per cent greater than on the kilowatt-hour basis.

KILOWATT-HOUR NOT THE CORRECT BASIS FOR LAMP-RENEWAL COSTS

Table X also shows that the kilowatt-hour cost basis is not a fair one for lamp-renewal costs. This is true because it is inevitable that with the decrease in total wattage of lamps the renewal costs per kilowatt-hour should increase in the same proportion. For example, a 16-cp lamp of one watt per candle

TABLE X

COMPARISON VALUES OF NEW HIGHER-EFFICIENCY LAMPS AND PRESENT LAMPS

Lamps Compared	Useful Life of Lamp in Hours	First Cost of Lamp in Cents	Kilowatts per Lamp	Lamp-Hours per Kilowatt-Hour	Candle-Hours per Kilowatt-Hour	Cost of 1000 Candle-Hours of Light at 10c. per Kilowatt-Hour	Lamp Renewal Costs per			Income per Lamp per 1000 Hours' Service		
							Kilowatt-Hour	Lamp-Hour	1000 Candle-Hours	On Kilowatt-Hour Basis at 10c. per Kilowatt-Hour	On Lamp-Hour Basis at ½c. per Lamp-Hour	On Candle-Hour Basis at 31.2c. per 1000 Candle-Hours
GEM-filament, 40-watt lamp, 16-cp, 2.5-w.p.c.	500	20	0.04	25.0	400.0	25c.	1.0 c	0.04 c.	2.5 c.	$4.00	$5.00	$5.00
Ordinary-carbon filament, 50-watt lamp, 16-cp, 3.1-w.p.c.	500	16	0.05	20.0	320.0	31c.	0.64c.	0.032c.	2.0 c.	5.00	5.00	5.00
GEM-filament, 50-watt lamp, 20-cp, 2.5-w.p.c.	500	20	0.05	20.0	400.0	25c.	0.8 c.	0.04 c.	2.0 c.	5.00	5.00	6.24
GEM-filament, 45-watt lamp, 16-cp, 2.8-w.p.c.	1000	20	0.045	22.2	355.5	28c.	0.44c.	0.016c.	1.25c.	4.50	5.00	5.00
Ordinary-carbon filament, 56-watt lamp, 16-cp, 3.5-w.p.c.	1000	16	0.056	17.84	285.4	35c.	0.3 c	0.02 c.	1.0 c.	5.60	5.00	5.00
Tantalum-filament, 50-watt lamp, 25-cp, 2.0-w.p.c.	800	60	0.05	20.0	500.0	20c.	1.5 c.	0.075c.	3.0 c.	5.00	5.00	7.80

or 16 watts total, would, at the same price per lamp, cost three times as much per kilowatt-hour as the present lamp.

To keep renewal costs per kilowatt-hour unchanged would require that the costs of higher-efficiency lamps should diminish in the same ratio as the efficiency is increased. This can not logically be expected, as improved lamps will tend to cost more rather than less. It would be correct practice, therefore, to drop the kilowatt-hour as a basis for lamp-renewal costs and take the cost per candle or equivalent light.

THE STANDARD FOR THE NEW LAMP

Returning to Exhibit A, a careful study of the tables thereunder shows that the minimum disturbance to central-station operating results, renewal costs, and particularly to the company's income, is given by a lamp of 25 per cent increased candle-power, *i. e.,* the new 20-cp, 50-watt lamp. It has been decided, therefore, to standardize on this lamp, and to make the new standard lamp (to replace the present 16-cp, 3.1-w.p.c. lamp) a 20-cp, 2.5-w.p.c. lamp with the same total wattage of 50 watts, and not a 16-cp, 40-watt lamp.

The same reasoning would indicate that in the case of the tantalum lamp a 25-cp, 50-watt lamp would be advisable.

Besides the advantages shown by Exhibit A, there are the following good reasons for this plan.

A higher candle-power incandescent lamp is needed to cope with competition of the Welsbach gas light, whose candle-power value is high.

Many consumers, particularly the desirable consumers, will spend a given amount of money for light in any event, and it is rational to anticipate this fact by giving them the increase in the candle-power of the lamp, instead of necessitating an increase of installation to accommodate more lamps of the present candle-power.

The plan follows the practice adopted by gas companies at the time of the introduction of the Welsbach lamps, where the improvement in efficiency is given in a very large measure in increased candle-power, which practice has proved so satisfactory to the gas business.

The plan gives the central-station company the same output

TABLE VIII

TOTAL COST OF LIGHT PER 1000 HOURS' SERVICE OF 20-CP NEW GEM-FILAMENT LAMP (AT VARIOUS EFFICIENCIES)

INCLUDING COST OF LAMP RENEWALS AND POWER AT VARIOUS RATES SHOWN

LAMP PRICE 20C. (LAMP LIFE AS GIVEN BY TABLE II)

(Minimum costs are underlined and starred)

(Results graphically shown in Figure 8)

Lamp Efficiency in Watts per Candle	Total Watts per 20-cp Lamp	Lamp Renewal Costs per Kilowatt-Hour in Cents	Total Cost of Light (Power and Lamp Renewals): Cost at 1c. per Kilowatt-Hour	Cost at 2c. per Kilowatt-Hour	Cost at 3c. per Kilowatt-Hour	Cost at 4c. per Kilowatt-Hour	Cost at 5c. per Kilowatt-Hour	Cost at 6c. per Kilowatt-Hour	Cost at 7c. per Kilowatt-Hour	Cost at 8c. per Kilowatt-Hour	Cost at 9c. per Kilowatt-Hour	Cost at 10c. per Kilowatt-Hour	Cost at 12c. per Kilowatt-Hour
2.1	42	2.7	$1.55	$1.974	$2.39	$2.81	$3.23	$3.65	$4.07	$4.49	$4.91	$5.33	$6.17
2.2	44	1.95	1.29	1.74	2.18	2.61	3.06	3.50	3.94	4.38	4.92	**5.26***	**6.14***
2.3	46	1.43	1.11	1.58	2.04	2.50	2.96	3.42	3.88	**4.34***	**4.80***	5.26	6.18
2.4	48	1.06	0.99	1.47	1.95	2.43	2.91	**3.39***	**3.87***	4.35	4.83	5.31	6.27
2.5	50	0.8	0.90	1.40	1.90	2.40	**2.90***	3.40	3.90	4.40	4.90	5.40	6.40
2.6	52	0.614	0.83	1.36	1.88	**2.40***	2.92	3.44	3.96	4.48	5.00	5.52	6.56
2.7	54	0.469	0.79	1.33	**1.87***	2.41	2.95	3.49	4.03	4.57	5.12	5.66	6.74
2.8	56	0.37	0.76	**1.32***	1.88	2.44	3.01	3.56	4.13	4.68	5.24	5.81	6.93
2.9	58	0.29	0.74	1.33	1.91	2.49	3.07	3.65	4.23	4.81	5.39	5.97	7.13
3.0	60	0.23	0.73	1.34	1.94	2.53	3.14	3.74	4.34	4.94	5.54	6.14	7.34
3.1	62	0.183	**0.73***	1.35	1.97	2.59	3.21	3.83	4.45	5.07	5.69	6.31	7.55

per consumer as at present given, thus avoiding the necessity of having to increase the number of consumers or the number of lamps connected per consumer, which would necessitate a possible increase in distributing expense.

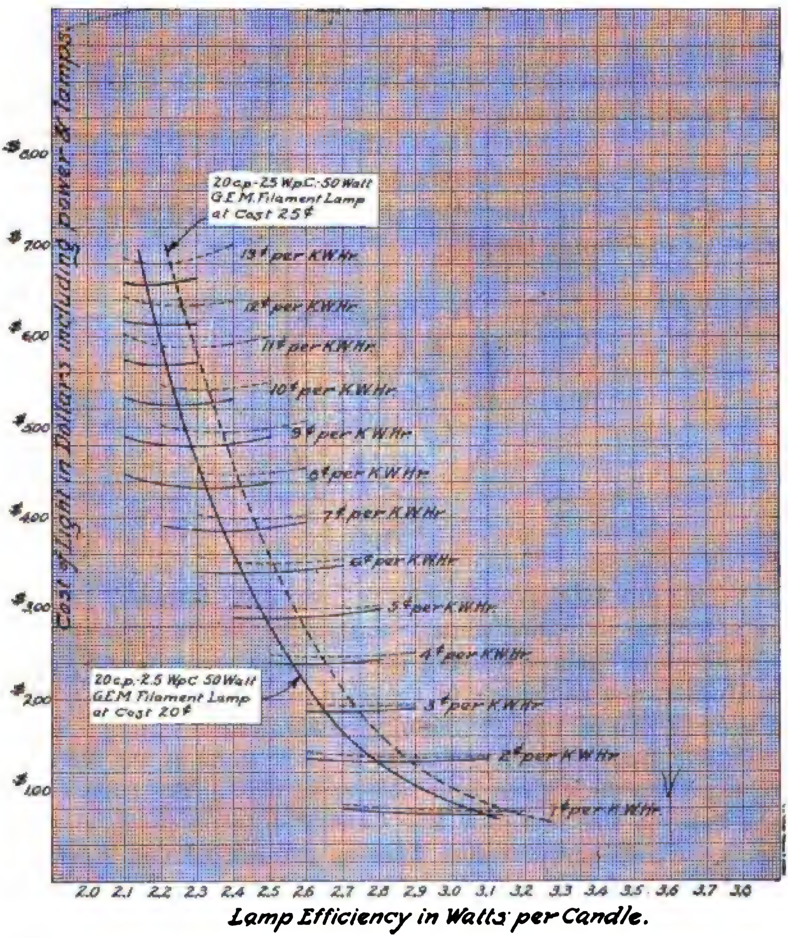


FIG. 8—CURVES GIVING MINIMUM COSTS OF LIGHTING (INCLUDING POWER AND LAMP RENEWALS) WITH THE NEW GEM-FILAMENT, 50-WATT, 20-CP LAMP AT DIFFERENT EFFICIENCIES AND AT DIFFERENT RATES PER KILOWATT-HOUR (SEE TABLE VIII)

The plan keeps down lamp-renewal cost per kilowatt-hour. The new 20-cp, 50-watt lamp, comparable in life with the

present 16-cp, 3.1-w.p.c., gives a derived unit (by lowering the voltage 4 per cent) of 16-cp, 45 watts total with 1000 hours' life—a comparable lamp to the present 16-cp, 3.5-w.p.c. lamp—thus providing the new lamp for conditions requiring such lamp life.

The proposed plan does not contemplate dispensing with lower candle-powers and wattages. There will be smaller units—30 watts, 20 watts—and other sizes made with the new GEM filament. The tendency will be, however, to go above and below the present 16-cp standard.

THE NEW LAMP RATING AND LABEL

The following illustration shows the proposed label for the new GEM-filament lamp:

FIG. 9

This new label possesses many interesting features. It will be noted that only total wattage and voltage markings are given. Candle-power values will not be shown, as these have become confusing, due to the use of the term in so many varied ways: Candle-power is used to express concentrated values due to reflection from supporting frames in such lamps as the Nernst; to express values given by reflectors used with the lamp as in the case of the Meridian and General Electric units, and so forth. Candle-power values have as a result of this indefinite use become misleading and confusing, and it has been considered desirable to omit them from the lamp label and to give them only when required, and then fully and accurately defined as "mean horizontal," "mean spherical," "values with a given form of reflector," and so forth.

Inasmuch as the sale of electric light is made largely on the watt-hour basis and not on the candle-hour, the proper unit is really watts per lamp, instead of candle-power. This practice

is along the lines of gas practice, where the burners are generally rated in cubic feet consumption, rather than in candle-power values.

Further good reasons for this plan are as follows:

It permits the adoption of even total watt values per lamp, as 50-watt, 30-watt, 25-watt, 10-watt, *et cætera,* instead of the fractional values now given.

The filament is rated to burn at an even degree of heat or incandescence, thus insuring more uniform performance as regards individual lamps.

The appearance of the lamps in service should be more uniform, as a slight variation in candle-power is not as noticeable as a variation in degree of incandescence or efficiency.

By eliminating the candle-power from the label, and absolutely fixed standards of candle-power as an essential to quality or good service, and by substituting therefor only watts per candle as a comparative basis, which standard can be varied to suit varying conditions, it will be possible for central stations to gradually advance their standard of efficiency from time to time to meet changing conditions.

It will be observed that the new lamp label has three voltage markings shown arranged in a vertical column in steps of two volts apart. These voltages are known as "top," "middle" and "bottom" voltages, or first, second and third voltages.

Customers requiring lamps of maximum efficiency—2.5-w.p.c.—will order lamps whose "top" labeled voltage or first voltage corresponds to the circuit voltage.

Customers requiring a lamp of slightly lower efficiency—2.65-w.p.c.—will order lamps whose "middle" labeled voltage or second voltage corresponds to the circuit voltage.

Customers requiring lamps of still lower efficiency—about 2.8-w.p.c.—should order lamps whose "bottom" labeled voltage or third voltage corresponds to the circuit voltage.

For example, take a lamp labeled as shown in Figure 9.

This lamp on a circuit of 112 volts will be burning at maximum efficiency 2.5-w.p.c. and full wattage of 50 with a useful life of about 500 hours; or

The same lamp on a circuit of 110 volts will give 10 per cent less candle-power with an efficiency of about 2.65 w.p.c., total watts about 47.5, and a useful life of about 750 hours; or

The same lamp on a circuit of 108 volts will give 20 per cent less candle-power with an efficiency of about 2.8-w.p.c., total watts about 45, and a useful life of about 1000 hours.

By adopting this method as a standard rating, all lamps can be more exactly suited to existing conditions than on the present basis of rating.

THE GENERAL POLICY FOR THE NEW LAMPS

What shall be the general policy for central stations to adopt with regard to the new lamp?

Accepting the standard agreed upon, namely, 50-watt, 20-cp lamp, central stations can have their option of adopting the new lamp either at "top," "middle" or "bottom" labeled voltage, as described in the foregoing description of label, and of thus giving their consumers

The highest efficiency available with total output unaffected, or

Lower efficiencies with reduction of output and lessened renewal costs resulting from longer life.

The change in renewal costs is given in Table X, column No. 5 (see also Table II and Figure 2, which show renewal costs of the present and new lamps per kilowatt-hour at various efficiencies).

Progressive practice should lead all central stations now using the 3.1-w.p.c. lamp to adopt in its stead the new 20-cp, 2.5-w.p.c. lamps at full efficiency, thereby keeping their watt consumption per lamp the same as at present. On this plan for the same useful life their renewal costs would remain unchanged on the correct basis of cost per candle, or on the kilowatt-hour basis would be increased by the small amount of 0.16 cent per kilowatt-hour.

Central-station companies at present using 3.5-w.p.c. lamps could adopt one of the following:

	Reduction in Watt Consumption per Lamp	Change in Lamp Renewal Cost per Kw-Hour
20-cp, 50-watt lamp (top labeled voltage)......	6.0 watts or 10.7 per cent	+0.514 cent
18-cp, 2.65-watt lamp (middle labeled voltage) ..	7.5 watts or 13.4 per cent	+0.273 cent
16-cp, 2.8-watt lamp (bottom labeled voltage) ..	10.0 watts or 18.0 per cent	+0.160 cent

The middle labeled voltage step would seem desirable for the present 3.5-w.p.c. station, as it shares the improvement with the consumer, giving 12 per cent more light, with 15 per cent less wattage. Present 3.5-w.p.c. lamp-renewal costs are very low, and most stations could afford the slight increase therein for the new lamp. With the present lamps there appears to be need of an intermediate efficiency between 3.5 and 3.1 watts per candle, *i. e.*, about 3.3 watts per candle. The new lamp at middle label voltage gives equal life to a present 3.3-w.p.c. lamp and should therefore satisfy this intermediate need.

EFFICIENCY OF NEW LAMP, GIVING MINIMUM LIGHTING COSTS

The minimum cost of lighting to the consumer paying for light on the kilowatt-hour basis at different rates will be secured with that efficiency which makes the sum of lamp renewals and cost of current a minimum. Estimating these costs as shown in my previous paper on efficiencies, we have the values for the new GEM lamp given in Table VIII and Figure 7. This table and curves show that for all rates above 5 cents per kilowatt-hour a consumer would obtain his light at a minimum cost, including cost of purchasing his own renewals by using the new 2.5-w.p.c. lamp.

The accepted practice supplies lamp renewals free and saves the consumer this part of the expense. It would seem, therefore, that this full efficiency of 2.5 watts per candle would be the desirable one for central-station companies to supply, because at any lower efficiency the consumer could afford to buy his own lamps and would save money by so doing. Enlightened and progressive central-station practice finds benefit in making the consumer's interest its own, and should therefore supply the lamp that secures a minimum lighting cost, *i. e.*, the new 2.5-w.p.c. lamp.

THE POLICY FOR LAMP RENEWALS WITH HIGHER-EFFICIENCY LAMPS

The control of lamp renewals by central-station companies is shown by both practice and theory to be a necessary condition for securing and insuring the best lighting results. The cost of lighting, of which the lamp renewal is a part, can unquestionably be made less to consumer when the central station purchases and supplies the lamp. This is so because the central-station company

purchases intelligently where the average consumer purchases unintelligently, generally choosing a poor-quality, long-life, low-efficiency lamp and paying therefor the highest retail price.

Experience shows that central stations must supply the lamps to insure the use of lamps of the maximum efficiency and provide lighting service at the minimum cost to consumers. In practice we find that where the consumer is left to purchase his lamp, the first cost and life of the lamp becomes of greater importance than the efficiency of lamp and consequent cost of light. In proof of this we note that there are to-day no 3.1-w.p.c. lamps used on central-station circuits in this country except where the companies furnish renewals. It is well known that where the practice prevails of making the consumer buy his own lamp, as in Europe, lamps of only the lowest efficiencies are used, namely, 4 and 5 watts per candle, and that there is little demand for any higher efficiencies or inducements held out to the lamp manufacturers to supply such. We may conclude therefore, that the new 2.5-w.p.c. lamp at full efficiency would not be adopted by the average consumer were he left to purchase his own lamp renewals.

To secure the introduction and use of higher-efficiency lamps it is necessary for central-station companies to furnish renewals. If central-station companies agree that it is very desirable to have the new lamp of the same total wattage as the present lamp in order that income may not be impaired, then it becomes necessary for the lighting company to furnish renewals of this lamp to their consumers to secure its adoption. Otherwise, consumers will purchase the lamp in higher voltages with reduced wattages per lamp and longer life, resulting in impairment of income by the differences in the wattage of the lamps.

This seems to me a strong argument for as full control of the new lamps as is now the case with the present lamps; that is a free renewal supply. In any event, central stations should supply the new lamps to their customers at as low a cost as possible to replace the present carbon-filament lamp on some one of the following plans:

First—Where the rates are fair or well maintained with some available margin, the additional costs of renewals, which, as shown herein, are very slight, can be absorbed in the present rates and the new lamps supplied free on the same basis as the present lamps.

Second—Where rates are very low with no margin available, the rates can be increased by the small margin necessary to cover the slightly increased cost of lamp renewals. On rate systems which charge by lamp-hour, lamp-month or lamp-year, this increase can be readily made. On regular watt-meter systems it can be effected by a slight increase in the kilowatt-hour rate. With the introduction of a higher-efficiency lamp, such an increase in rates is logical and justifiable, as the customer is returned many times the value of the small increase in charge (see Tables III and IV).

Third—Where rates can not be increased by reason of laws in force and otherwise, or where rates are low, with no margin available for this additional renewal expense, it would appear to be necessary to charge customer an additional sum per lamp, represented by the difference between the cost of the new lamp and the present lamp.

In general for the new GEM-filament lamp it is to be hoped that central stations will adopt the first plan and thus insure the use of the higher-efficiency lamps.

RENEWALS WITH THE TANTALUM LAMP

For lamps like the tantalum, costing materially more than the present lamp, the second or third plans may be adopted, thus providing consumers with the lamps at the minimum cost by charging only the additional cost therefor. Assuming a price for the tantalum lamp of 75 cents retail, 60 cents to central stations now buying at 16 cents, and with a lamp life of 800 hours on direct current, the renewal cost will be 1.5 cents per kilowatt-hour, which is 0.86 cent more than present 3.1-w.p.c. lamp-renewal costs. An increase of 1 cent per kilowatt-hour in rates would therefore fully cover the increased cost to the central station and give consumer 60 per cent more light for only a 10 per cent increase in cost at a rate of 10 cents per kilowatt-hour.

Or consumers can be supplied with renewals of tantalum lamps at the increased cost over present lamps. As compared to present 3.1-w.p.c. lamps at 16 cents—the life of which (500 hours) is five-eighths that of the tantalum (cost 60 cents), we find the relative cost of the tantalum lamp to be sixty times five-eighths, or 37.5 cents. Deducting cost of present lamp (16 cents), gives 21.5 cents, or, in round figures, 25 cents more for the tan-

talum lamp. This is about the price of a Welsbach mantle. Electric companies could therefore meet Welsbach competition with the tantalum lamp by supplying renewals at the same price as Welsbach mantles—without increasing renewal costs over free renewals with present 3.1-w.p.c. lamps.

THE EFFECTS IN THE ANALOGOUS CASE OF THE WELSBACH LAMP

The general effects of the introduction of high-efficiency lamps can perhaps best be determined by referring to the results of an analogous case in the gas business. We all well remember what consternation was caused among gas companies with the advent of the Welsbach mantle gas lamp several years ago. The improvement produced by this lamp was a much greater one relative to the old gas burner than that of the new lamps in comparison with the present lamps. It was feared generally among gas companies that the Welsbach lamp would bankrupt them, and the majority of gas companies looked upon this lamp with such great disfavor that for a long time they would not undertake to supply them to their customers. How different the actual results were from those expected we all well know and the present development of gas lighting attests. Far from being detrimental to the gas business it was its salvation and gave it a new lease of life in the lighting field, proving substantially the benefit to a lighting company of benefiting the consumer.

GENERAL CONCLUSION

Why should not electric lighting companies derive similar benefits from the introduction of higher-efficiency incandescent lamps? It would appear illogical to expect otherwise, or that any improvement in efficiency of the electric lamp would not yield central stations as desirable and proportionately as full returns as those obtained in the gas business.

The demand for more light is insistent, and its use appears to increase with every improvement in lighting devices. The electric lighting industry has suffered for the want of higher-efficiency lamps, its growth has been retarded, its possibilities curtailed.

Now with the advent of incandescent lamps giving improvements of 20 and 30 per cent and the promise of still greater gains,

the restrictions of the past will be gradually removed and the industry is sure to expand and develop to the full measure of the opportunity the improvements afford.

There should be no question on this point or of the wisdom of supplying consumers electric light at the lowest possible cost by the employment of high-efficiency lamps and the adoption of a profitable low-rate system of charges—thus giving electric lighting the freest rein and enabling it to distance its competitors and maintain that supremacy which it rightly should hold in the lighting field.

These considerations should prompt each and every central-station manager to enthusiastically welcome and promptly utilize the new improved lamp and give the benefit to his consuming public from whom his company's business is derived and upon whom its stability and success depends.

APPENDIX

COST OF PRODUCING A KILOWATT-HOUR WITH DIFFERENT LAMP EFFICIENCIES FOR THE SAME NUMBER OF LAMPS SUPPLIED

The following determinations are placed here, so as to avoid confusing the discussion in the body of the paper (page 605).

In the paper, Table V and Figure 5, the deduction is made as to the cost of producing a candle-hour of light with lamps of different efficiencies.

For those who wish to determine the cost on a kilowatt-hour basis for an equal number of lights the data in Table VI and Figure 6 are given herewith.

Taking the cost of producing an equal number of lamp-hours of light expressed in kilowatt-hours, we have the values given in Table VI and the per cent relations of higher-efficiency lamps to the present 16-cp, 3.1-w.p.c. lamp shown by the curves in Figure 6.

This Table VI and Diagram 6 express a somewhat different result from those in Table V and Figure 5 in the body of the paper, as here the candle-power values do not count, but only the lamp-hours in equivalent kilowatt-hours.

From the curves in Figure 6 we see that, as compared to the cost given per kilowatt-hour per lamp by the present 16-cp, 3.1-w.p.c., 50-watt lamp (curve No. 1) :—

TABLE VI

(Results diagrammed in Figure 6)

TABLE SHOWING RELATIVE COSTS OF PRODUCING A KILOWATT-HOUR WITH DIFFERENT LAMP EFFICIENCIES FOR THE SAME NUMBER OF LAMPS COVERING LAMP RENEWAL COSTS AND OTHER COSTS THAT ARE AFFECTED BY CHANGE OF EFFICIENCIES FOR SAME NUMBER OF LAMPS SUPPLIED

Lamps Compared	(1) First Cost of Lamp in Cents	(2) Efficiency of Lamp in Hours	(3) Useful Life in Hours	(4) Fixed Charge Cost in Cents per Lamp per Year	(5) Cost of Lamp Renewals per Kw-Hour in Cents	(6) Fixed Cost per Kilowatt-Hour in Cents on the Basis of Consumption per Lamp per Year						
						5 Kw-Hours	10 Kw-Hours	20 Kw-Hours	30 Kw-Hours	40 Kw-Hours	60 Kw-Hours	100 Kw-Hours
GEM-filament, 40-watt lamp 16-cp, 2.5-w.p.c.	20	2.5	500	60.0	1.0	12.0	6.0	3.0	2.0	1.5	1.0	0.6
Ordinary-carbon filament, 50-watt lamp 16-cp, 3.1-w.p.c.	16	3.1	500	75.0	0.64	15.0	7.5	3.75	2.5	1.87	1.25	0.75
GEM-filament, 50-watt lamp 20-cp, 2.5-w.p.c.	20	2.5	500	75.0	0.8	15.0	7.5	3.75	2.5	1.87	1.25	0.75
GEM-filament, 45-watt lamp 16-cp, 2.8-w.p.c.	20	2.8	1000	67.5	0.44	13.5	6.75	3.375	2.25	1.69	1.125	0.675
Ordinary-carbon filament, 56-watt lamp 16-cp, 3.5-w.p.c.	16	3.5	1000	84.0	0.3	16.8	8.4	4.2	2.8	2.1	1.4	0.84
Tantalum-filament, 50-watt lamp 25-cp, 2.0-w.p.c.	60	2.0	*800	75.0	1.5	15.0	7.5	3.75	2.5	1.875	1.25	0.75

* Approximate value on direct current.

TABLE VI—*Continued*

Lamps Compared	(7) Fuel and Station Labor Expense per Kw-Hour Delivered at Lamp as Assumed at Several Values	(8) Total Cost per Kilowatt-Hour (Sum of Columns 5, 6 and 7), on Basis of Consumption per Lamp per Year						
		5 Kw-Hours	10 Kw-Hours	20 Kw-Hours	30 Kw-Hours	40 Kw-Hours	60 Kw-Hours	100 Kw-Hours
GEM-filament, 40-watt lamp 16-cp, 2.5-w.p.c.	1 c. per kilowatt-hour	14.0	8.0	5.0	4.0	3.5	3.0	2.6
	½c. " "	13.5	7.5	4.5	3.5	3.0	2.5	2.1
	0 c. " "	13.0	7.0	4.0	3.0	2.5	2.0	1.6
Ordinary-carbon filament, 50-watt lamp 16-cp, 3.1-w.p.c.	1 c. per kilowatt-hour	16.64	9.14	5.39	4.14	3.51	2.89	2.39
	½c. " "	16.14	8.64	4.89	3.64	3.01	2.39	1.89
	0 c. " "	15.64	8.14	4.39	3.14	2.51	1.89	1.39
GEM-filament, 50-watt lamp 20-cp, 2.5-w.p.c.	1 c. per kilowatt-hour	16.8	9.3	5.55	4.3	3.67	3.05	2.55
	½c. " "	16.3	8.8	5.05	3.8	3.17	2.55	2.05
	0 c. " "	15.8	8.3	4.55	3.3	2.67	2.05	1.55
GEM-filament, 45-watt lamp 16-cp, 2.8-w.p.c.	1 c. per kilowatt-hour	14.94	8.19	4.815	3.67	3.13	2.565	2.115
	½c. " "	14.44	7.69	4.315	3.17	2.63	2.065	1.615
	0 c. " "	13.94	7.19	3.815	2.67	2.13	1.565	1.115
Ordinary-carbon filament, 56-watt lamp 16-cp, 3.5-w.p.c.	1 c. per kilowatt-hour	18.1	9.7	5.5	4.1	3.4	2.7	2.14
	½c. " "	17.6	9.2	5.0	3.6	2.9	2.2	1.64
	0 c. " "	17.1	8.7	4.5	3.1	2.4	1.7	1.14
Tantalum-filament, 50-watt lamp 25-cp, 2.0-w.p.c.	1 c. per kilowatt-hour	17.5	10.0	6.25	5.0	4.375	3.75	3.25
	½c. " "	17.0	9.5	5.75	4.5	3.875	3.25	2.75
	0 c. " "	16.5	9.0	5.25	4.0	3.375	2.75	2.25

First—The new GEM 16-cp, 2.5-w.p.c., 40-watt lamp (curve No. 4) gives a less cost up to 40 kilowatt-hours' consumption per lamp per year (or 1000 hours per year use of a 40-watt lamp).

Second—That the new GEM 20-cp, 2.5-w.p.c., 50-watt lamp (curve No. 5) averages only about three per cent higher in cost up to 50 kilowatt-hours' consumption per lamp per year and does

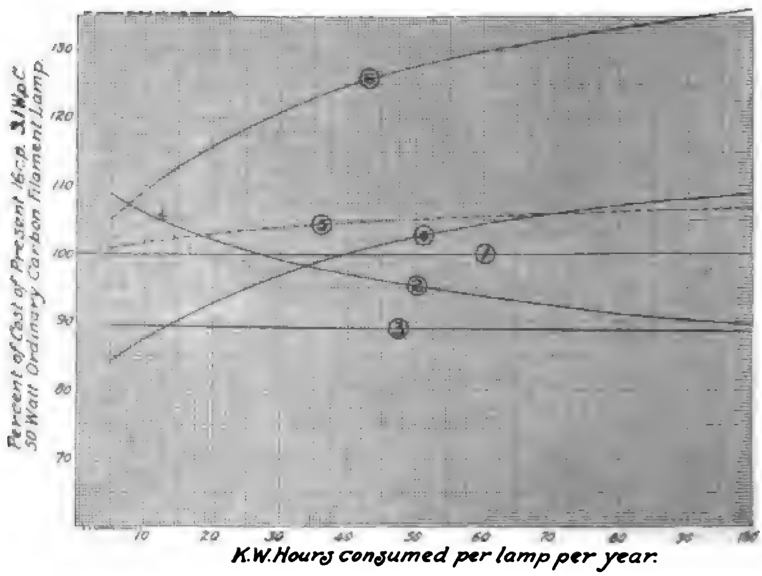


FIG. 6—CURVES SHOWING RELATIVE COST OF PRODUCING A KILOWATT-HOUR WITH LAMPS OF DIFFERENT EFFICIENCIES FOR SAME NUMBER OF LAMPS EXPRESSED IN PER CENT OF COSTS GIVEN WITH PRESENT 16-CP, 3.1-W.P.C., 50-WATT LAMPS (SEE TABLE VI)

Fuel and station labor cost, 1 cent per kilowatt-hour
Lamp costs—New GEM filament, 20 cents
Tantalum " 60 cents
Present " 16 cents

1.	Present carbon-filament,	16-cp,		3.1-w.p.c.,		50-watt lamp		
2.	" "	"	16	"	3.5	"	56	"
3.	New GEM	"	16	"	2.8	"	45	"
4.	" "	"	16	"	2.5	"	40	"
5.	" "	"	20	"	2.5	"	50	"
6.	Tantalum	"	25	"	2.0	"	50	"

not exceed seven per cent increase at 100 kilowatt-hours' consumption. For this increase in cost we must remember we are here giving 20 candle-power as compared to 16 candle-power, or 25 per cent more candle-power for the aforesaid slightly increased cost.

Third—That the new GEM 16-cp, 45-watt lamp (curve No.

3) gives 11 per cent less cost. Comparing this with its present mate on life, the 16-cp, 3.5-w.p.c. lamp (curve No. 2), we see that the cost with the latter lamp is higher up to the limit of values assumed.

Fourth—That the new tantalum lamp (curve No. 6) shows 10 to 20 per cent increased cost up to 30 kilowatt-hours' consumption, and a higher cost beyond this point. It must be noted here again, however, that we are now giving 25 candle-power of light or 36 per cent more light than with the present lamp.

DISCUSSION

THE PRESIDENT: There are a great many points in this paper that could hardly be absorbed in reading it once. I think the gist of the paper is summed up in one paragraph on page 610: "The central-station-cost standpoint is not the correct basis on which to determine the proper efficiency of lamps where light is sold by the kilowatt-hour. It neglects to consider the effect upon the customer and the selling end of the business. Whether a central station supplies free lamp renewals or not, and whether its costs are thereby changed or unaffected, the success of the business demands the lowest practicable cost to the consumer—that is, it requires the use of high-efficiency lamps—of that efficiency which gives the lowest cost of light (including power and lamp renewals) at the rate paid."

MR. A. C. DUNHAM (Hartford, Conn.): I consider the metalized-filament lamp the greatest improvement that has been made in electrical appliances in the last five years. We find that the two complaints most usual among customers are—in the first place, they can not get enough light for the money they pay. They pay all the money they can afford, but are hungry for light and do not feel that they get all they ought for the money they pay. Next to that is the complicated bill, I believe, which we do not feel the effect of at all. We have doubled our output, in the last ten years, every three and one-half years. We have done it without any solicitors. I believe it has been due entirely to a steady decrease in the cost of light. For instance, since the new systems of distributing light—so as to make all light delivered useful—have been in use, our increase in light put out has been much more rapid. The first four months of this year we increased our

output $28,000, and of that about $4500 a month was light, without any more than the usual increase in the number of our customers. I believe this result was entirely due to the use of the Meridian and such other lamps as place the light just where it is wanted. We have a very good gas company in Hartford, as well managed as any gas company in the country, but we have positively no competition whatever in the matter of lighting; the gas company sells stoves mostly. The new GEM 20-cp lamp at 50 watts gives the station as much income as it ever had, and it gives the customer 25 per cent more light. I believe that the increase in the value of the output will go on so fast that before this lamp gets down to two watts—which it will—the station will not feel that decrease at all. It has one quality that is very valuable. We have been in the habit of taking off our 16-cp lamps every 400 hours, because they blacken; we do not think it pays to give nominal candle-power, and not the real candle-power. But this lamp does not blacken; you can run it to the limit of its useful life. A 20-cp lamp goes down to a little below 17 candle-power in 600 hours and then goes out. We are not obliged to take in the lamps and test them with a photometer and renew them. The lamp burns out and you put on a new one, and you get nearly 17 candle-power at the close of the life of the lamp: and that looks like an increase of 50 per cent in the life of the lamp—a real increase, which in our business is what we want. Then, there is another thing about it. An increase in candle-power for the same money means a reduced price to the customer. We have reduced the price steadily for five years, and every time we reduce the price we increase the output and increase the profit. We have gone up from 48 per cent on the gross of our output to 55 per cent in five years, and we have done it entirely through the lower prices. I am very anxious to have this GEM lamp produced in a 35-watt lamp, giving about 12.5 candle-power, for the cost of the present 10-cp lamp, and giving the central station the same income.

I imported a tantalum lamp when it first came out in Europe. It has certain drawbacks; it can not be used on alternating current without the loss of half its value, and it can not be used in any place where there is vibration. In testing the candle-power of the lamp we found that if we left it on the circuit during its life it would burn 700 hours, but if we took it off the circuit and tested

it every 50 hours it would burn only 300 hours. It can not be disturbed after the first 150 hours without shortening its life.

PROFESSOR CLIFFORD: I think it is very important in emphasize that with the gain in efficiency of the new metalized-filament lamp you do not sacrifice the use of the lamp on alternating-current circuits; it is as good on alternating as on direct-current service.

I hope Mr. Willcox will not urge his recommendation to add a small increase to the rate. I believe that so long as human nature is what it is you can not increase the rate, no matter how many curves you may carry around that will appeal to the intelligence of the man who takes time to consider them. It seems to me it is like the buying of any product—a man does not care what the percentage of fat is in his milk, or how much proteid there is in his beef; he wants to know how much the milk costs a quart and the beef a pound. You may carry any analyses or convictions you please to the intelligent man, but it seems to me that you can not afford to add anything to your rates. Enter, then, on your campaign of education, sell the high-efficiency lamp outright if you will, but, with the present agitation on questions of municipal ownership, diminish rather than increase the charges for service.

THE PRESIDENT: That is the kind of talk we like to hear from a college professor.

We will now take up the next paper, *The Edison System of Southern California,* by Mr. R. H. Ballard, of Los Angeles.

The paper was read by Mr. Ballard, as follows:

THE EDISON SYSTEM OF SOUTHERN CALIFORNIA

In asking me to prepare a paper telling the story of The Edison Electric Company of Los Angeles, President Blood stated that it was not his desire that the system be considered from an engineering standpoint. There are many reasons why I should not care to undertake the reporting of the rather complicated system in an engineering way, principal among which is the fact that I am not an engineer. You will doubtless say that all other reasons are immaterial. I have endeavored in the following paper to give you an idea of what we have, some of the difficulties we have met in acquiring the power plants, the basis on which all of the plants are operated as one system, and some of the methods employed in selling the product.

BEGINNING

From the spring of 1895 to the spring of 1896 there was operated, first just outside of the city limits of Los Angeles, and later just inside (by reason of the extension of the corporate limits of the city), what might be called a miniature electric lighting plant. During this time efforts were being constantly made to secure a regular city franchise for this plant, but not until the spring of 1896 was this accomplished; at that time, after a franchise had been twice refused, an old one turned up and was promptly purchased by the owners of this little plant. This franchise had never been used and would lapse in just two weeks' time unless light were furnished to the City Hall. By an almost superhuman effort, and with the assistance of one of the street railway companies (on whose poles lighting wires were strung), one cluster of lights was turned on in the City Hall on the night before the day on which the franchise would have lapsed. Thereupon the West Side Lighting Company was incorporated, with a capitalization of $500,000 and an authorized bond issue of $300,000, and the more serious troubles of finance and the securing of business began, as the fight was then against a financially and politically well-entrenched company. The legality

of the franchise was attacked, rates were cut, obstacles were put in the way of financing, and other troubles, large and small, constantly appearing, the building up of the business was no small task. The fight was carried on fiercely, but on account of the never-despair attitude of the West Side lighting people a foothold was secured. Later a third company entered the field and the fight was re-opened, this time on a three-cornered basis, in a more severe manner than the original one.

The wonderful growth of Southern California has helped materially in building up the present extensive system from this small beginning, and with the careful handling of the business, from a financial and operating standpoint, capital was interested in sufficient amounts to take care of the increasing business and to acquire many other properties by purchase and consolidation. In the ten short years between 1896 and 1906, the business has expanded to such an extent that at present electric current is being furnished to twenty-two separate cities and towns and gas to eleven. All of the properties have been consolidated into the present The Edison Electric Company, with a capital of $10,000,000 and an authorized bond issue in the same amount.

THE WATER-POWER BEGINNING

One of the companies taken over by The Edison Electric Company through consolidation was the Redlands Electric Light and Power Company, which was organized in July, 1892. At that time electric transmission of power was certainly in its infancy, if it could be said to have been born. The market demand for this power was so located as to render necessary the installation of a plant capable of transmitting power varying distances of from 5 to 20 miles, and equally well adapted for use in incandescent lighting, arc lighting and alternating-current motor service. The directors of the Redlands company were informed by their engineer that to make the plant a commercial success they should install a tri-phase system then in experimental use in Tivoli, near Rome. The first attempt to get the large manufacturing corporations to bid on this type of apparatus was unsuccessful, all claiming that the idea was too far in advance of practice for them to undertake it; but after a number of months' correspondence the General Electric and Westinghouse companies were induced to bid on specifications drawn

by the Redlands engineer, and the apparatus was finally built by the General Electric Company. This plant, which goes under the title of "Mill Creek No. 1," on the Edison system, began operation in October, 1893, and is still in regular daily use, operating in synchronism with all water-power and steam plants on the Edison system. As a legacy from this first plant, the company has still in use the first tri-phase generator, the first synchronous motor and the first induction motor ever put into commercial use by the General Electric Company.

The development of high-head water-power on the Pacific slope in 1892 was in as experimental a condition as the transmission of electric power, and the promoters of the Redlands company installed their plant at the head of the valley without entering the cañon, as has since been the Edison company's universal custom. The power was generated by diverting the stream of Mill creek into a steel pipe 30 inches inside diameter, 7250 feet long and having a pressure head of 360 feet. Later, this pipe was extended 3000 feet further up the valley to the mouth of the cañon, giving a total net available head of 510 feet, under which the plant is now operating.

Three 250-kilowatt generators were finally installed in this station, current being generated at 2200 volts stepped up through transformers to 10,000 volts, and transmitted to Riverside, a distance of 28 miles, taps being made from Redlands and Highlands from the same line. Later, the voltage was raised to 33,000. The appliances, both hydraulic and electric, in use at that time were extremely crude as compared with the highly specialized types of construction in use to-day, and naturally the difficulties to be overcome were numerous. Nevertheless, while the plant is not as efficient as other plants on our system, it has furnished us in the past and is still furnishing us with a considerable amount of power, and since the first experimental stage was over, the cost of operation and maintenance of the plant has been small.

LATER POWER DEVELOPMENT

While the development of a market for the power from the Mill Creek No. 1 plant was slow, each year showed the possibilities of electric power transmission, and in 1896 surveys were begun for the construction of a water-power plant in the Santa Ana cañon, using the water of Santa Ana river, on the

other side of the mountains in which the Mill creek plant is located. It was expected that the plant would transmit approximately 4000 kilowatts to Los Angeles, a distance of 80 miles. This plant was subsequently built and began operation in 1898, being what is now termed "Santa Ana River No. 1" plant of the Edison system. The type of hydraulic construction since adopted by the company was first used in this plant. Water is conveyed through a series of tunnels along the cañon walls, on a grade of approximately ten feet to the mile, to the head of a pressure main consisting of two steel pipes, each 30 inches inside diameter, 2200 feet long, with a net effective head of 728 feet. The effectiveness of this type of construction has been thoroughly demonstrated by the fact that since the water has been turned into the tunnels it has never been turned off for any fault of the canal system, nor has any money whatever been expended thereon for repairs. The total length of canal line is approximately three miles, three-fourths of the way being driven through solid granite mountains. There are four 3-phase, 750-kilowatt generators installed and the current is stepped up through air-blast transformers to 33,000 volts.

The growth of the business necessitating additional power, during the succeeding years several plants were constructed in the immediate vicinity of the first installations. Proceeding up the Mill creek stream, the No. 2 plant, with a canal line of three and one-half miles, a water head of 620 feet and a capacity of 750 kilowatts, was the next plant put in operation.

"Mill Creek No. 3" was next constructed, with 1960 feet head, 7 miles of canal and a capacity of 3000 kilowatts.

Then followed "Santa Ana River No. 2" and "Lytle Creek" plants, both having 560 feet head and capacity of 2000 and 1000 kilowatts respectively. The current is stepped up from all of these plants to 33,000 volts.

The total capacity of the six plants figures 10,500 kilowatts.

TRANSMISSION SYSTEM

Everything on the system is connected in "Y" with the neutral grounded through two circuits of No. 0 hard-drawn copper wire. Some of the plants are located 5 or 6 miles from the main line. Plants are also on extreme ends.

The pole line carries two circuits of No. 0 copper a distance of about 80 miles to Los Angeles.

Substations are installed all along the line, in which the current is transformed and sent out on different circuits of 2200, 10,000 and 15,000 volts. From the general distributing station in Los Angeles circuits are sent out to various substations located in and around the several beach towns, consequently we are delivering power from the mountains over a distance of 129 miles, almost in a straight line to the ocean, with numerous branches all along the line. The present transmission line figures a total length in 33,000 volts of 110 miles; in double circuit 10,000 and 15,000-volt transmission, 300 miles, and the 2200-volt distributing systems in the several towns in which we are operating aggregate 750 miles. A great many difficulties have been encountered and overcome in perfecting this transmission system, an important one being the great distance we are from centres of manufacture. The growth of the business has been so rapid that it has seemed physically impossible to estimate the needs quite far enough ahead. This growth may in a way be noted from the fact that last year the peak load of the entire system increased 94 per cent over the peak load of the previous year. Insulator troubles have come up more or less frequently; an insulator good for 35,000 volts in the mountains would not stand up at 15,000 volts on the coast.

STEAM PLANTS

In the general Los Angeles distributing station is installed 4000 kilowatts in steam turbines, and we are just now installing an additional unit of 7500 kilowatts, making a total of 11,500 kilowatts for the station. These machines have proven good for a 50 per cent overload. The installation at this station is of the very best, comprising remote-control switchboard, motor-driven switches, all concrete construction, and provision has been made for the distribution of 2200 and 15,000-volt circuits and for the receiving of incoming circuits from the power plants, 33,000 and 66,000 volts. The 66,000-volt lines will be those of our new 20,000-kilowatt Kern river plant, which is nearing completion. In other parts of the system there are installed a number of small units feeding into the general transmission line, whose aggregate rated capacity is 4000 kilowatts, good for some over-

load. All of the steam equipment is used as auxiliary for helping over the peak and for reserve in case of shorts or breakdowns along the line.

GENERAL OPERATING CONDITIONS

The six hydraulic and seven steam plants, varying from an ordinary, old-fashioned Wheelock simple engine to a Curtis turbine, are run in multiple, feeding into the one general transmission system. A great many comments have been made and some wonderment expressed upon the surety of our service, operating under these conditions, but no serious disadvantages have so far been experienced.

The speed of the hydraulic plants is set at two per cent above normal, which guarantees their handling maximum load before any steam plants that are floating on the line cut in.

From six in the morning until midnight one of the 2000-kilowatt turbines at Los Angeles is rotated as a motor, for the purpose of correcting the power factor, and to cut in in case of trouble.

The success of this multiple operation depends first on the proper construction of the plants, and then on a thorough organization of the working forces, with fixed rules to govern fixed conditions. All stations are inter-connected with a private telephone system.

The natural trend of the country suggests high-head power plants, as the streams, while containing comparatively small amounts of water, have natural falls of from 200 to 300 feet to the mile. All of these plants are as noted, high-head, but having in operation the Mill Creek No. 3 plant with its 1960 feet fall, the lesser ones suffer in comparison.

Other than the use of extra care in devices at the intake for straining out all solid matter, the operation of a plant with 840 pounds pressure does not differ materially from that of 300 pounds pressure. When we consider that the spouting velocity of the water discharging through the pipe line of the No. 3 plant is 22,000 feet per minute, the necessity for this extreme care is apparent.

The low cost of operating water-power plants and the all-day load picked up in the vast area covered by the lines by reason of our ability to furnish power on very low rates, more than justify the extra investment in steam plants to insure the day service and carry the lighting load over the peak.

In many respects Southern California may be considered an ideal country for electric transmission and distribution. There is no doubt that the comparative freedom from windstorms, frost and sleet, with certain atmospheric conditions, helps materially. At the same time, there are few places in America where within a distance of twenty miles energy will be passing over lines enveloped in a snowstorm and through orchards covered with orange blossoms and surrounded with roses.

KERN RIVER

Work is rapidly nearing completion on our first Kern river plant, designed to generate 20,000 kilowatts and transmit same at 75,000 volts a distance of 120 miles to Los Angeles receiving station. It is expected that within a few weeks the plant will be in operation. In this plant the hydraulic construction work consists of a masonry dam 36 feet high, anchored on bed rock, which forms a small lake or settling basin from which the water is turned into the canal, the flow being regulated by gates operated hydraulically. The canal consists of a series of 19 tunnels eight and a half miles in length, 9 feet by 9 feet in cross-sections, drilled through solid granite and lined along either side with a cement wall six inches in thickness, smoothly plastered and troweled, to give increased carrying capacity. These tunnels have a grade of 6.8 feet per mile and a water-carrying capacity of 450 second-feet. The water is discharged from the end of the tunnel into a small forebay to which is connected the intake of the pressure main. The pressure main consists of a circular inclined tunnel, having a slope of approximately 76 degrees to a point 200 feet from the power-house, where it changes to the same grade as the canal. This inclined tunnel has a riveted steel lining, 7.5 feet interior diameter, solidly backed with concrete between the lining and the outer walls of the tunnel. The lining terminates where it leaves the tunnel at its lower end in ten branch pipes necessary for delivering water to the four generators and two exciters, under a net effective head of 865 feet.

In the concrete power-house will be installed four 5000-kilowatt rated capacity, tri-phase generators, with extended shaft, carrying on each end one water-wheel. The combined output of the two wheels at each generator is 10,750 horse-power, capable of delivering from generator to switchboard a 50-per cent overload

of the rated capacity of each generator. In addition there are two exciters, each 250 kilowatts rated capacity, equipped with water-wheels. The four banks of transformers will step the current up from 2400 to 75,000 volts.

The 120-mile transmission line consists of a line of steel towers designed to carry three circuits of No. 0000 wire erected on a private right-of-way 100 feet wide. The two circuits will be used to carry the output of this first plant, the third to be strung later for carrying the output of a second plant immediately above the one now approaching completion.

The wide right-of-way will permit of the erection of an additional line of towers to transmit the output of other proposed plants on the Kern and Kings rivers.

The towers are constructed of angle iron, being 12 feet square at the base and varying in height from 30 to 60 feet, according to the nature of the country traversed. Both cross-arms are of 10-inch channel iron, the upper one being 24 feet long and the lower one 18 feet. These towers are spaced, on an average, 700 feet apart on the level, and vary from that distance to 300 feet in hilly country. They are designed to stand the greatest strain that can be put upon them, and are both strong and graceful in appearance.

FUTURE POWER PLANTS

The plans of the company contemplate the eventual construction along the Kern river of four water-power plants, in addition to the one now approaching completion. These plants are numbered on our records in order proceeding up the cañon, and with the several intervals between the intake of one plant and the power-house of the one above it, the plants will utilize the fall of the river for about 80 miles. The water head will vary from 340 to 1200 feet, and will give a total output of 50,000 kilowatts at the ordinary low-water flow of the stream. The type of construction adopted for the No. 1 plant, with slight variations to meet the conditions of each particular plant, will be carried on throughout the work.

In addition to the Kern river, the company controls water rights, on which some little work has been done, for an extensive system of water-power plants on Kings river, and other smaller plants on the Santa Ana river. After the completion of the

Kern river plants it is probable that work will be proceeded with on these plants, and an additional capacity of nearly 60,000 kilowatts added to the system.

GAS PLANTS

From time to time we have acquired by construction and purchase the gas plants in eleven of the districts in which we handle the electric lighting and power business. Primarily, the idea of our controlling the gas situation is for protection of the electric, as with our power facilities for the furnishing of electric lighting, we do not ordinarily push the gas lighting business to any extent, confining the operation of these plants as far as possible to the selling of gas for heating purposes. The ownership of a gas plant in a town in which we are operating electrically is often helpful in the settling of municipal questions, and in case of competition we have two weapons with which to harass the competing company. At the same time, gas operation is not confined strictly to the helping of the electric business, as owing to climatic conditions and the low price of crude oil from which the gas is made, as compared with coal or other eastern fuel, we are able to sell gas to our consumers for one dollar per thousand cubic feet in most of our gas districts, and still make a little money from the operation.

THE MARKET

Light

Climatic conditions give us a large floating population both winter and summer, and this class wants the best that can be obtained that will produce the least amount of daily and hourly labor. Being, as a rule, possessed of a goodly share of this world's riches, they are free spenders, and the constant daily association has its effect on the whole community. It is said that one can live as economically in Southern California as in any part of the country, but one does not do it.

This has its bearing on the demand for electric lighting, both in business and residence sections. The merchant must advertise freely, and under these circumstances there is no better advertising than a well-illuminated store equipped with electric signs. Seldom is a residence built without electric wiring, and, in addition to the modern lighting equipment controlled by con-

venient switches, many are fitted with electric appliances for heating and minor cooking. In a large way this accounts for the fact that while California ranks as the twenty-first state in population, it occupies fifth place in producing income from electricity for lighting purposes and second in the use of electricity for power purposes.

Particular attention has been paid to the business of sign lighting, and as a result of our attendance at the Denver convention last year we have recently adopted a successful policy of supplying the sign and taking care of it on a flat-rate basis.

Electric laundry irons are good income producers. During a period of eighteen months several thousand of these were put out in laundries and private residences and a carefully prepared record of the results obtained induced us recently to take up this class of business in a wholesale way by furnishing irons free to consumers.

Power

Southern California does not rank as a manufacturing centre, consequently the demand for current in large units for manufacturing purposes must necessarily be limited. However, the amount of power used by electric railways, railway shops, ice and cold storage plants, brick yards, planing mills, machine shops, *et cætera,* is very considerable, as all of these take part in the construction of buildings and the development of the country.

As the backbone of successful water-power operation is naturally the handling of a good day load, we have aggressively and persistently kept at this line of the business, until it is safe to say that the present percentage of power users having electrically-driven machinery is larger than the percentage of those using other motive power, notwithstanding the fact that the natural fuel of the country is oil, which can be obtained at a low figure. In order to induce many of the consumers to make the change, we have had to buy up steam and gasolene plants aggregating hundreds of horse-power. These plants have been sold again, principally to mining camps and other places inaccessible from an electric distributing system standpoint.

By this policy the load curve up to the peak is being straightened, but more business is still necessary to bring this curve to

a straight line, starting and ending with the figure representing the total installed capacity of water-power plants.

There is a certain kind of power business which is perhaps peculiar to Southern California, and this is of importance, owing to the conditions under which the power is required. Owing to the fact that for six months in the year no rain falls, it is necessary to do a large amount of irrigating. Only a small proportion of the water needed has a natural flow, and as a consequence the requirements of the country have largely to be met by pumping water from beneath the surface. The pumping season usually lasts from the first of May until the end of October; fortunately, just at the time of the year when we have the least demand for electricity for lighting purposes. As a rule, the pumping plants are operated during the day hours only, and the very great number of these plants that we are operating in all our districts is a considerable factor in the building up of our day load.

In the campaign of obtaining business careful attention has been paid to four important factors: advertising, soliciting, care of the business and courteous treatment of consumers.

Advertising is good—soliciting is better; a combination of both is excellent. By care of the business we mean prompt attention to the consumer's every want, adjusting troubles, be they his fault or ours. Courteous treatment under all circumstances makes friends who advertise for us.

ORGANIZATION

The officers of the company comprise president, three vice-presidents, general manager, secretary, treasurer, superintendent and general agent.

Subsidiary departments are in charge of these officers, the responsibility being divided sufficiently to obtain the best results through the work of specialists along different lines.

The power development department, under the supervision of Vice-President H. H. Sinclair, builds all power plants and turns them over to the operating department, ready for operation.

In handling the operation of the properties and the additions thereto, the superintendent divides responsibility under three heads, *viz.*, electric generation, electric distribution and gas manufacture and distribution, with assistant superintendents in charge.

Responsibility for commercial and financial matters is divided between the other officers reporting to the general manager.

The president, Mr. John B. Miller, takes an active part in the direction of the business, keeping in touch with all important transactions, and receiving reports from the several department heads, through the general manager.

The system is divided into fourteen districts, in charge of district agents or local managers. In each we have also a district foreman, who is a technical man, receiving instructions from the superintendent, through the agent.

It is the custom to hold weekly meetings of department heads for general discussion of the business as a whole, and bi-monthly general meetings of all district agents, in which papers are read and questions on which agents may be in doubt are brought up for discussion in the form of question boxes. Quarterly the foremen of the system meet with the superintendent for general discussion of the handling of the technical side of the business.

A large part of the success the company has enjoyed is due to the enthusiasm and loyalty of everyone connected with the business. These features are very much in evidence throughout the company, from president to office boy.

I am indebted to Messrs. Sinclair, Selig, Pearson and Kennedy of our company, for assistance in preparing this paper.

THE PRESIDENT: This is an interesting paper, but hardly needs any discussion.

Secretary Eglin read letters from Norfolk, Minneapolis and Saratoga Springs, inviting the association to hold its next convention at those places.

THE PRESIDENT: We will now take up the last paper, *Design and Manufacture of Hydro-Electric Installations,* by Mr. E. F. Cassel, of Milwaukee. In the absence of Mr. Cassel, the paper will be abstracted by Mr. C. A. Tupper.

Mr. Tupper presented an abstract of the following paper:

DESIGN AND MANUFACTURE OF HYDRO-ELECTRIC INSTALLATIONS AS A WHOLE

Prior to the development and perfection of electrical transmission the utility of water-power was confined to work to which it might be applied in its immediate vicinity. The only means of transmission were either by transmitting the water itself, converting the power into compressed air, or mechanical transmission by means of wire cables, and so forth. Under these conditions the usefulness of water-power was as restricted as the means for utilizing it. The use of hydraulic turbines was practically confined to the driving of small individual installations. Wheels of 200 to 300 horse-power were considered large. The amount of water available for the power required was usually unlimited. The purchaser seldom required the assistance of the consulting engineer in determining what type of wheel was needed and where to order it. The sales department consisted of a catalogue and scores of testimonials.

Efficiency was of little consequence, and, thanks to the foresight of the designing engineer, the usual testimonial was: "Your wheel gives more power than required." Connection between the turbine and driven shaft was by means of belt, rope drive or gearing, making one design available for many different speeds and a few designs sufficient for all speeds. Regulation was sometimes attempted and the results as often ignored.

The development and perfection of electrical apparatus marks a new departure in hydraulic power requirements, the most important development being long-distance transmission. Every mile added to the practicable distance of transmission of electrical energy either increases the market for an already developed water-power or brings into the market one heretofore undeveloped. Instead of running a factory or factories in its immediate vicinity the waterfall is now called upon to supply power for towns and cities within a radius of many miles. There is no longer "more power than required." From all quarters comes the demand for efficiency; 3000-hp, 4000-hp, 10,000-hp wheels are required and specified as glibly as the 200-hp and 300-hp wheels

of earlier days. Efficiency demands direct connection of the turbine to the generator, a point of more than passing importance in that one design is no longer available for a large number of speeds, and the turbine as a consequence becomes only a part of a complete machine, all parts of which must be considered as a whole in order to secure the results demanded by modern practice. Step by step the cry for efficiency has forced improvement in hydraulic design and manufacture, until to-day the principal opening left for improvement would seem to be in the design and manufacture of hydraulic power installations as a whole.

The marvelous electrical development of the past few years has been accomplished by the electrical engineer and principally in conjunction with the steam engine as prime mover. This fact has in itself been a serious drawback in the development of proper designs for hydro-electric installations, as it has led the electrical engineer to call often upon the hydraulic engineer to fulfill requirements which were, if not impossible, to say the least, undesirable.

Experience is slowly remedying this trouble and impossible specifications are not as usual as formerly, but there is still room for improvement. Consulting engineers now universally recognize the necessity of conforming in general design to the requirements of hydraulic practice, but, unfortunately, many are still prone to accept the results achieved by the hydraulic turbine in small units and as an individual machine as sufficient data for their study in the design of a modern hydro-electric installation. A short study of a few specific points involved will illustrate the necessity of designing these installations as a whole and emphasize the advantage of the manufacture of the plant as a complete machine instead of an assembly of individually manufactured parts.

In steam engine practice the boiler pressure may be and often is specified. Were the water pressures under which hydraulic turbines may be designed confined within as close limits as the steam pressures under which steam engines are designed, the difficulties of hydraulic design would be largely removed. This is only one of the problems to be met. The maintaining of efficiencies under widely varying pressures in the same plant, the maintaining of uniform speed under widely varying volumes of

water at different times of the year without serious loss in efficiency, the maintaining of close regulation with inelastic water instead of elastic steam, and other equally difficult points, should plainly point out the necessity of giving the design of the hydraulic turbine different consideration and treatment from that of the steam engine when used in connection with electric generating plants if it be desired that these plants shall produce the best possible results.

In a hydraulic installation the water pressure is a fixed physical condition. The minimum amount of water available is also a physical condition, which can not be varied at the will of the designer. These essentials being fixed factors in the problem, it follows that to secure the best efficiency and produce the most satisfactory results equipment must be furnished best suited to these fixed conditions. Too often this self-evident fact is either ignored or not treated with sufficient importance. Specification after specification is received by the manufacturer with the number of revolutions fixed from the standpoint of the generator desired to be furnished. In some few cases these speeds are found to be correct, but in many cases they have been arrived at from some catalogue speeds and powers which are approximately near to the estimates of the purchaser. A very superficial study of the possibilities of the modern high-speed turbine runner will show how absolutely it is unfitted for high efficiencies except under exact conditions of head and speed—a comparatively slight variation in either being fatal to the very theory upon which these runners are designed; nevertheless, so great is the temptation in competition to reduce weights and prices by means of the use of high speed that this design is often recommended, even by engineers who should know better, for conditions under which its use is undesirable and even impossible.

In designing a hydraulic installation, the head and quantity of water being known, the size of wheel and number of revolutions best suited for high efficiencies can be determined. If only the hydraulic part of the installation were to be considered this would require little co-operation between the manufacturers of the various parts of the equipment. But there remains other questions to be considered, as, for instance, the number of units to be used. This will largely be determined by what the power is to be used for. In some cases large units would be better than

a larger number of smaller units. In this determination consideration will be taken of the point as to whether or not the size of unit results in using a standard or special type of generator. If the limits of speed proposed in the turbine do not quite permit of a standard generator, the use of a different *specific* speed in the *design* of the turbine runner will often permit of the use of a standard generator and still preserve in the turbine the high efficiencies required under varying conditions of head and volume of water available and power required, resulting in a decided economy, both in first cost and in amount of water used in operation—an important item to the purchaser.

This having been determined, the general design of the turbine will be influenced by floor space available, foundation expense, and so forth. In some cases a more expensive type of turbine and generator will result in a large economy in installation expense.

The revolutions, size and type of unit having been established, the generator is finally determined. To arrive at this we have had to take into consideration a great many more essential points than merely trying to produce a turbine or a generator *which might each fully comply with specifications, but still not be as suitable for the work to be performed or as economical in installation as a proper modification arrived at as outlined above.*

It is true that up to this point it can be argued that the work is that of the consulting engineer and not properly in the province of the manufacturer. This argument, however, is born of the lack of opportunity in the past to discuss these features as a whole with the manufacturer. Manufacturers of turbines are interested in selling turbines and are not interested in electrical specifications or requirements. Manufacturers of generators are not interested in the difficulties of the turbine manufacturers. If the plant as a whole fails to produce the desired results, each has an opening to shift responsibility; whereas, if the manufacturer were equally interested with the consulting engineer and the purchaser in the actual results of the installation as a whole, the results achieved would be easily determined and the responsibility fixed. Instead of usurping any of the functions of the consulting engineer, such a manufacturer should be of invaluable assistance, both in determining the type of plant best suited for the installation as well as the details of manufacture, assem-

bly and installation, and also in determining, without prejudice, the value of the results achieved.

A most important point in the design and manufacture of hydro-electric installations, and one which unites the different parts of the design into one problem, is the question of governing. In spite of all that has been written and emphasized in connection with the governing problem of hydraulic plants, it must be admitted that common practice in this connection is directly contrary to the results of experience. Specifications *ad infinitum* are prepared and issued, specifying the results to be achieved by the governor without any notice being given or importance attached to either flywheel effect, inertia of water in penstock or draft tube, action of relief valve and other elements, all of which have a direct bearing upon what it is possible for a governor to do. With the specifications, separate bids are asked for the governing apparatus. The prevailing impression seems to be that all that has to be considered is the movement of the gates of the turbine within a given time.

If there is one element in a hydro-electric installation which must be considered in connection with all the other parts of the generating station, and which should be designed and furnished by the turbine manufacturer, it is the governor. The rotating parts of the generator and turbine, the relief valve, the penstock and draft tube, are as much a part of the governor as the fly balls themselves; yet, in spite of this, we find contracts let to one manufacturer for the turbine, to another for the generator, to another for the governor, and sometimes to another for the relief valves. If the plant in operation is not subjected to the severe conditions provided for in the specifications, the governing is said to be satisfactory. If it fails there is always someone else to blame. Had the plant been furnished by one manufacturer as a whole, all the elements connected with the question of governing would naturally have received proper consideration in the design, for the reason that the manufacturer's guarantees would be judged by actual results in operation and not by determining whether or not the governor furnished so many foot-pounds in so many seconds.

What applies to determining the guarantee of the manufacturer as to governing also applies to the question of efficiency. Were the entire installation designed, manufactured and guaran-

teed as a whole, the difficulty of determining results would be practically eliminated. There would be no further necessity for determining the efficiencies of the generator, turbine, exciter and exciter turbine separately, with the necessary allowance for thrust bearing friction, governor drives, *et cætera,* as at present. The same efficiency would be required, but would readily be measured by actual electrical output, and once determined there would be no shifting of responsibility in case of failure.

To sum up the matter, it appears to the writer that the personal interest which the manufacturers of a hydro-electric installation as a whole would have in the results actually achieved by the installation when in operation, induces a stronger tendency toward perfection in practice than the present method of manufacturing material in accordance with specifications, but with no responsibility as to whether or not such specifications may be right or wrong.

That this tendency would be in the direction of better practice, and, being so, would receive the hearty co-operation of engineers interested in this branch of engineering, we believe will be confirmed by all who will give the matter a little thought.

THE PRESIDENT: We will now receive the report of the committee on the president's address.

Mr. Scovil read the following report:

REPORT OF COMMITTEE ON PRESIDENT'S ADDRESS

To the Members of the National Electric Light Association:

The committee appointed to consider the president's address begs to report as follows:

In order that the matter of annual dues should receive the prompt consideration urged by the president, your committee recommends that a committee be appointed by the incoming president, and approved by the executive committee, to consider this subject, which has so much to do with the general welfare of the association, with instructions to report at the next annual meeting, so that if its recommendations are approved at that meeting the new rates can become immediately effective.

The recommendations concerning the Class C members have been met by the appointment of a special committee, which has already reported at an executive session.

The arrangement for offices in the new United Engineering Building, Thirty-ninth street, New York City, seems to be well considered and is such as should adequately meet the growing requirements of the association for its general office work.

As to the matter of general relations with the underwriters, your committee is decidedly of the opinion that in order to best conserve the interests of the members individually and collectively, and in order to maintain at all times the best possible conditions as to the fire hazards of electricity, as well as harmonious relations with the underwriters, we endorse the suggestion that a representative of the association be immediately retained by the association, who shall devote a part of his time to the questions arising in this connection.

The central exhibition idea has been successful this year. It should be continued wherever possible to make satisfactory arrangements.

The policy, adopted for this convention, of relieving local parties from the necessity of making financial arrangements for the annual meeting, judging from the experience of this meeting, is a wise one.

Respectfully submitted,

Committee, {
SAMUEL SCOVIL, Chairman,
T. COMMERFORD MARTIN,
ARTHUR WILLIAMS.

MR. ERNEST H. DAVIS (Williamsport, Pa.): I move that the report be accepted and referred to the incoming executive committee.

(The motion was carried.)

Mr. Paul Lüpke, editor of the *Question Box*, then presented the volume, and the introduction was read by Mr. John McFeeley, of Newark.

(This introduction will be found in Volume II of the proceedings.—EDITOR.)

The meeting then went into executive session.

EXECUTIVE SESSION

The report of the nominating committee was presented by the secretary, as follows:

The nominating committee for the election of officers and members of the executive committee begs to report as follows:

For president, Arthur Williams, New York City.

For first vice-president, Dudley Farrand, Newark, N. J.

For second vice-president, Alex Dow, Detroit, Mich.

For secretary and treasurer, W. C. L. Eglin, Philadelphia, Pa.

For members of the executive committee, to serve for three conventions: Charles R. Huntley, Buffalo, N. Y.; F. N. Tait, Dayton, Ohio; Louis A. Ferguson, Chicago, Ill.

Respectfully submitted,

Committee,
SAMUEL SCOVIL, Chairman,
JOSEPH E. MONTAGUE,
PERCY INGALLS,
J. T. COWLING,
JAMES I. AYER.

On motion of Mr. Davis, the report was received and accepted, and the gentlemen nominated were unanimously elected as officers of the association for the ensuing year.

PRESIDENT BLOOD: Gentlemen, a year ago you elected me as president of this association, at Denver, very much to my surprise. I had at that time no realization of what the office meant; no knowledge of what the association was doing; no comprehension of its work or its scope. I had no conception of its standing in the community. It did not take me long, however, to find out some of these things, or to see that I had a large task on my hands. At that time I asked your hearty co-operation. I have received it in every way; letters that I have sent out to the members have been promptly answered; inquiries have come to me and have been transmitted to various members, and they have

received the best attention. I have had the heartiest co-operation from those whom I have asked to prepare papers. I wish to thank all who have prepared papers for this convention, because they have done a great deal toward making it a success. I wish to thank at this time all the officers of the association who have co-operated with me. I wish to thank all of the companies and every individual member of the association; I want to give special thanks to the convention committee, to its chairman, Mr. Arthur Williams, and to the two other gentlemen who have done a large amount of work, Mr. Farrand and Mr. Eglin. The success of this convention comes from their hearty, constant, persevering and conscientious work.

You have to-day elected a new president. I bespeak for him the same consideration which you have shown me. There is no one connected with this association who is better known, no one who has done so much faithful work for it, no one who truly deserves the compliment as much as he does. I take pleasure in introducing to you Mr. Arthur Williams, your new president.

(To Mr. Williams.) Allow me, in the presence of this assembly, to place upon you the insignia of your office, the gold button.

MR. ARTHUR WILLIAMS: Mr. President and Gentlemen—I thank you for the honor you have conferred upon me. Were I unappreciative of such an honor I should be almost less than human. I bespeak the same hearty support you have given President Blood. I shall hope with the help of the officers, the executive committee and the membership at large, to turn over to my successor the association in the same splendid condition in which President Blood leaves it. He has given our committee his thanks for what we may have been permitted to do; to accomplish this we have had his hearty support, his suggestions and his help in innumerable directions. I feel that it would be doing less than justice to President Blood if we were to permit this meeting to close without an expression of our appreciation for the great work he has accomplished.

Again I thank you for the honor you have conferred upon me.

PRESIDENT BLOOD: At a meeting of the executive committee it was unanimously voted to take into this organization two honorary members. We have now on our list some fifteen or twenty, and the executive committee recommends at this session the names of Charles P. Steinmetz and T. Commerford Martin.

(On motion, the gentlemen were unanimously elected.)

President Blood appointed Messrs. Scovil and Davis a committee to escort Mr. Martin to the platform.

MR. MARTIN: I do not know whether it is ten days or ten dollars. [Laughter.] Mr. Blood, Mr. Williams, and good friends all: United with you in a common purpose, and I think a good purpose—the promoting and perfecting of one of the most beneficial industries the world has ever seen—I am glad to have done the little I did imperfectly toward promoting the success of this association. It is twenty-one years since I read my first paper before this body, and, God granting me health and strength, it will be twenty-one years more before I quit.

I appreciate this honor very deeply, and looking over the list of honorary members in the association and noticing the prominence and distinction of the names that are upon it, it is to me more than sufficient reward for all the work I have done to find myself placed in such an eminent category. I shall be glad to work under Mr. Williams just as diligently and enthusiastically as I have done under Mr. Davis and Mr. Blood and their brilliant predecessors.

Gentlemen, I thank, you, with best wishes for the future of this grand old association.

MR. SELIG: I move that this association, by a rising vote, express its appreciation of the work of the retiring president and executive committee.

The secretary presented the treasurer's report:

REPORT OF THE TREASURER FOR THE FISCAL YEAR ENDING DECEMBER 31, 1905

Cash on hand January 1, 1905	$6,206.89	
Petty cash in the hands of assistant treasurer	150.00	
		$6,356.89
RECEIPTS DURING FISCAL YEAR		
Class A dues 1904	$30.00	
" A " 1905	8,313.00	

Class B dues 1905	685.00	
" C " 1905	152.00	
" D " 1904	20.00	
" D " 1905	2,195.00	
" E " 1905	360.00	
Entrance fees Class A	1,350.00	
" " " B	530.00	
" " " D	250.00	
" " " E	360.00	
Municipal investigation fund	2,536.75	
Sale of badges Twenty-eighth Convention	48.00	
Advertisements in Proceedings Twenty-sixth Convention	50.00	
Advertisements in Proceedings Twenty-seventh Convention	965.00	
Advertisements in Proceedings Twenty-eighth Convention	945.00	
Sale of stenographic reports Twenty-eighth Convention	240.00	
Sale of publications	620.50	
		19,650.25
Total cash on hand during 1905		$26,007.14

DISBURSEMENTS DURING FISCAL YEAR

Drafts refused by bank, 1905	$30.00	
Class C dues refunded	15.00	
Salary assistant secretary and treasurer	2,500.00	
Clerical salaries	1,616.10	
General office rent	715.01	
General office expense	118.22	
Telephone rental and messengers	134.81	
Express and messengers	50.78	
Printing and stationery	283.73	
Postage and telegrams	501.76	
Expense of executive committee	338.70	
Expense 1905 *Question Box*	746.28	
Printing and expense of publications	5,667.40	
Miscellaneous expenses	164.53	
Expense membership committee	2,029.85	
Expense municipal plant investigations	2,115.25	
Office furniture and fixtures	198.67	
Legal services	421.50	
Expense tabulating statistics	61.30	
Traveling expenses	393.10	
Printing Proceedings Twenty-eighth Convention	1,404.95	
Expenses 1905 Convention	342.00	
Badges for 1905 Convention	224.94	
Expense district steam-heating fund	47.00	
		$20,120.88

STATEMENT OF FUND FOR EXPENSES OF COMMITTEE FOR INVESTIGATING THE PHOTOMETRIC VALUE OF ARC LAMPS

January 1, 1905	Balance on hand	$183.91	
	No receipts or expenses.		
	Balance on hand December 31, 1905		$183.91

MUNICIPAL PLANT INVESTIGATION FUND

January 1, 1905	Balance on hand	$2,680.45	
	Received during 1905	2,536.75	
	Total	$5,217.20	
	Disbursed during 1905	2,115.25	
	Balance on hand December 31, 1905		$3,101.95

DISTRICT STEAM HEATING COMMITTEE FUND

January 1, 1905	Balance on hand	$134.42	
	Disbursed during 1905	47.00	
	Balance on hand December 31, 1905		$87.42

STEAM TURBINE COMMITTEE

January 1, 1905	Balance on hand	$777.95	
	No receipts or expenses.		
	Balance on hand December 31, 1905		$777.95

RECAPITULATION

Cash in bank, and in hands of assistant treasurer January 1, 1905		$6,356.89
Receipts during the year 1905, as per detailed list		19,650.25
		$26,007.14
Disbursements during the year 1905, as per detailed list		20,120.88
Total cash on hand December 31, 1905		$5,886.26
Cash in bank December 31, 1905	$5,736.26	
Cash in hands of assistant treasurer	150.00	
		$5,886.26

CASH ON HAND DECEMBER 31, 1905, IN THE VARIOUS FUNDS AND COMMITTEES

Committee for investigating the photometric value of arc lamps	$183.91
Municipal plant investigation fund	3,101.95
District steam heating committee fund	87.42
Steam turbine committee	777.95
General fund	1,735.03
Total cash on hand December 31, 1905	$5,886.26

ASSETS

Cash as per statement	$5,886.26
Office furniture and fixtures	782.12
	$6,668.38

LIABILITIES

None except current bills.

Respectfully submitted,

W. C. L. Eglin, Treasurer.

To the President and Directors of the National Electric Light Association:

Gentlemen—I beg to advise that I have examined the accounts of the treasurer of your association for the fiscal year ending December 31, 1905, and certify to the correctness of the treasurer's report as submitted.

I also examined the accounts to and including May 14, 1906, and found all receipts and disbursements properly accounted for, and available cash in office and in bank as of that date to the amount of $16,089.44.

Respectfully submitted,

PAUL JONES, Auditor.

On motion of Mr. Burleigh, the treasurer's report was approved and filed.

On motion of Mr. Arthur Williams, a vote of thanks was passed to the Bell Telephone Company, of Atlantic City, N. J., for its courtesy and generosity in providing local telephone service to the members of the association during the convention.

On motion of Mr. Williams, a vote of thanks was extended to the Atlantic City Hotel Men's Association for many courtesies and for the admirable hotel arrangements made for the comfort of the delegates during the convention.

The following amendment to the constitution was adopted:

Article III, Section 2, first paragraph: Omit after "Class B" and substitute: *Instructors and teachers of engineering and related sciences as shall be in sympathy with and shall approve of the objects of the association, shall be eligible as members and shall be designated as Invited Membership Class.*

Article III, Section 2, third paragraph: Omit, and substitute: *Invited Membership Class shall have all the privileges of member companies, Class A, except the right to vote, to hold office, and to attend the executive sessions of the conventions. Such members shall be invited annually by the executive committee.*

Other business presented in executive session, including papers and reports, will be published separately for the use of Class A members.

On motion of Mr. Farrand, the convention adjourned.

ELECTRICAL EXHIBITION

In connection with the Atlantic City convention a very elaborate and interesting exhibition was held at Young's Pier by the following Class D members of the association:

LIST OF EXHIBITORS

Addressograph Company, Philadelphia, Pa.
A. F. Moore, Philadelphia, Pa.
Allis-Chalmers Company, Milwaukee, Wis.
American Circular Loom Company, New York, N. Y.
American-Diesel Engine Company, New York, N. Y.
American Electric Heater Company, New York, N. Y.
American Instrument Company, Philadelphia, Pa.
American Vibrator Company, New York, N. Y.
Automatic Refrigerating Company, Hartford, Conn.
Beck Flaming Lamp Company, New York, N. Y.
Buckeye Electric Company, Cleveland, Ohio.
Central Station, The, New York, N. Y.
Crocker-Wheeler Company, Ampere, N. J.
Curtis Advertising Company, Detroit, Mich.
Dearborn Drug and Chemical Works, New York, N. Y.
Duncan Electric Manufacturing Company, Lafayette, Ind.
Electric Storage Battery Company, The, Philadelphia, Pa.
Electrical Review, New York, N. Y.
Electrical World, New York, N. Y.
Excello Arc Lamp Company, New York, N. Y.
Federal Electric Company, Chicago, Ill.
Fibre Conduit Company, The, Orangeburgh, N. Y.
Fort Wayne Electric Works, Fort Wayne, Ind.
General Electric Company, Schenectady, N. Y.
General Storage Battery Company, New York, N. Y.
Gould Storage Battery Company, New York, N. Y.
H. B. Camp Company, New York, N. Y.
H. W. Johns-Manville Company, New York, N. Y.
Illuminating Engineering Publishing Company, New York, N. Y.
John L. Gleason, Jamaica Plain, Mass.
Mayer and Englund Company, Philadelphia, Pa.
Metropolitan Engineering Company, Brooklyn, N. Y.
National Brake and Electric Company, Philadelphia, Pa.
National Metal Molding Company, New York, N. Y.
Niagara Tachometer and Instrument Company, Niagara Falls, N. Y.
Oneida Community, Limited, Oneida, N. Y.
Phelps Company, The, Detroit, Mich.
Philadelphia Electrical and Manufacturing Company, The, Philadelphia, Pa.
Pittsburgh Transformer Company, Pittsburgh, Pa.
Sangamo Electric Company, Springfield, Ill.
Shelby Electric Company, The, Shelby, Ohio.
Simplex Electric Heating Company, Boston, Mass.
Southern Exchange Company, New York, N. Y.
Standard Paint Company, The, New York, N. Y.
Standard Vitrified Conduit Company, New York, N. Y.
Stanley-G. I. Electric Manufacturing Company, Pittsfield, Mass.
Tipless Lamp Company, New York, N. Y.
Wagner Electric Manufacturing Company, New York, N. Y.
Westinghouse Companies' Publishing Department, Pittsburgh, Pa.

Works of The National Conduit & Cable Co.
HASTINGS-ON-HUDSON, NEW YORK
Executive Offices, 41 Park Row, New York

SANGAMO
WATTMETER

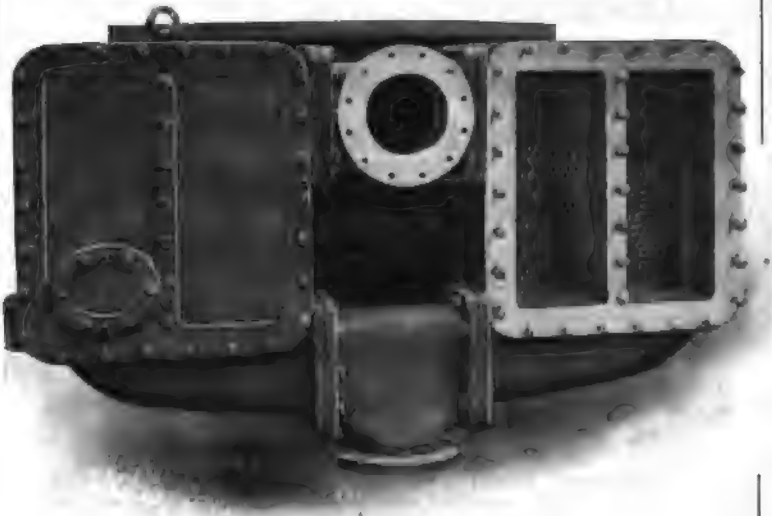
For Direct and Alternating Current

Electric Appliance Company

GENERAL SELLING AGENTS

CHICAGO DALLAS
SAN FRANCISCO NEW ORLEANS

ALBERGER



ALBERGER TURBINE BASE CONDENSER

Surface, Barometric and Jet

Condensers

Vacuum and Circulating Pumps, Cooling Towers

WAINWRIGHT

Heaters, Coolers, Expansion Joints

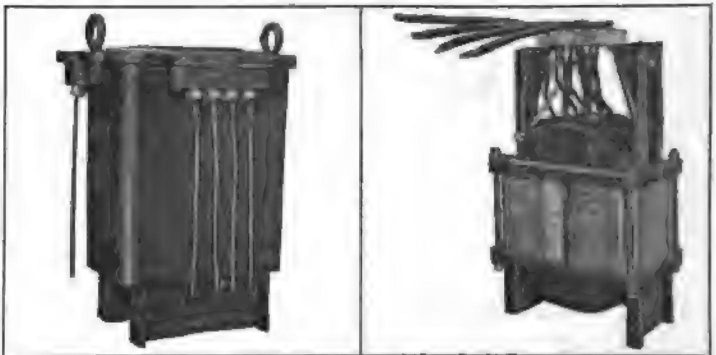
ALBERGER CONDENSER COMPANY

95 Liberty Street, New York

BRANCH OFFICE

205 La Salle Street, Chicago, Ill.

Westinghouse Transformers



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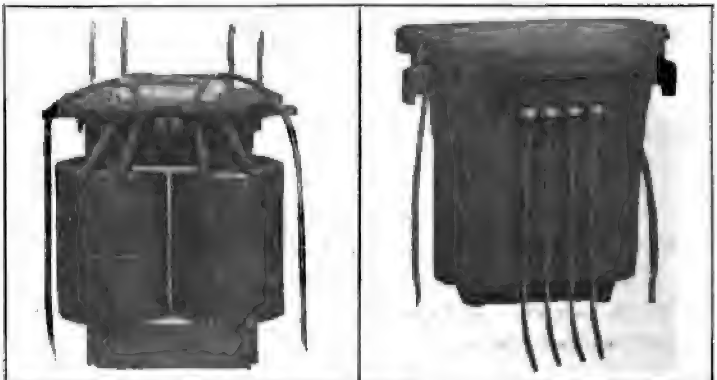

Type C, Core Type

Westinghouse Electric & Mfg. Co.

Sales Offices in all Large Cities **Pittsburgh, Pa.**

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